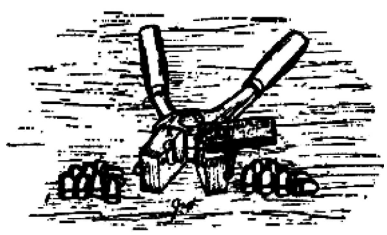
HANDLOADER'S MANUAL

A Treatise on Modern Cartridge Components
and their Assembly by the Individual
Shooter into accurate Ammunition
to best suit his various
purposes

By

EARL NARAMORE
Major, Ordnance Department Reserve
The Army of the United States

Sketches by LT. COL. JULIAN S. HATCHER



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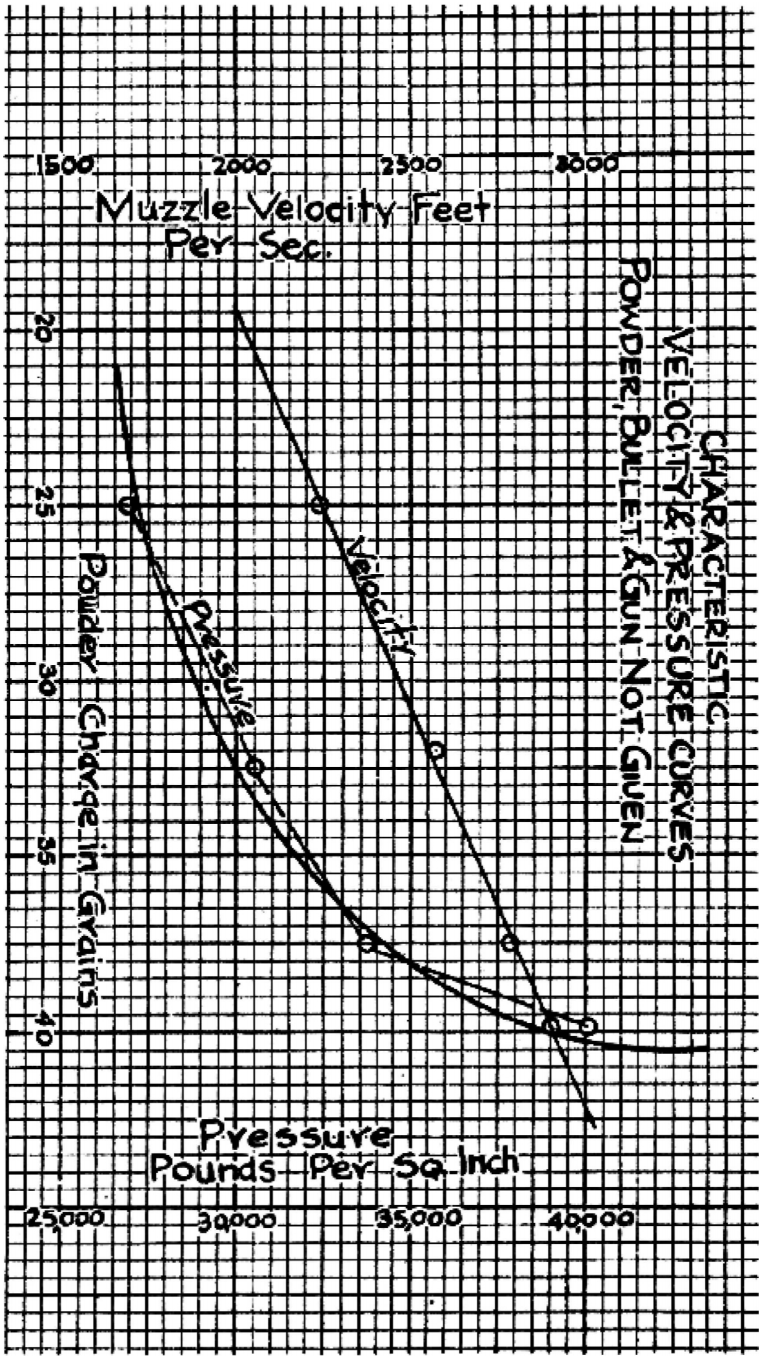

The frontispiece illustrates a characteristic velocity and pressure curve plotted for different charges as explained on pages 51 and 52. This is a typical curve and does not represent figures published anywhere or for any definite rifle, cartridge or bullet, it is seen that the velocity curve is virtually a straight line, thus showing that as the powder charge is increased the velocity is raised in a proportional amount. This means, there-fore, that within the limits of the powder charges published, *it* is entirely feasible to estimate the velocity of any other powder charge by direct proportions as explained on page 51.

It is seen also that the pressure increase is not a straight line, nor is it in direct proportion to the powder charge used. The amount of curvature of the pressure line depends largely on the characteristics of the cartridge and the particular powder used. The quicker burning powders intended primarily for reduced loads or mid-range work will show a sharper pressure rise for a given charge increase than will the larger grain, slower burning powders. Consequently, for such faster burning powders, the maximum pressure level, safe to use, is lower than normal for the full load of slower burning powders usually for maximum loads. At low pressure levels, i.e., when using reduced charges, practically all powders will show relatively small pressure increases in proportion to the increase in charge. However, at or near the maximum charges published for a given powder in any cartridge, the pressure increases at a very rapid rate and out of all proportion to a unit increase in powder charges as illustrated by the sharp upward turn of the curve at its upper end. This characteristic pressure curve illustrates that between the charges published for any powder, it is perfectly safe to interpolate or calculate the pressure developed for any intermediate charge by direct proportion which would, of course, be the same as if the pressure values were read off the dotted straight line connecting two adjacent plotted points. This curve also illustrates that it is dangerous to attempt to estimate the pressures developed by extrapolation or extending the pressure curve beyond the maximum charges published for use with a powder. A few grains more powder, or under some circumstances, even a slight increase over the maximum charge may develop infinite pressure.

The published powder charges and ballistics obtained represent actual tests made with present day components. Many re-loaders seem to go on the theory that the powder charges published are actually cut or lowered a grain or two for the ballistics shown and, therefore, they will play, smart and deliberately increase the charge to offset this modesty on the manufacturer's part. For intermediate or law pressure loads it is seen that this can do no harm in the way of developing dangerous pressures, BUT for full charges or maximum powder charges published, such a mistaken idea may very well result in excessive pressures with resulting damage to the gun and possible injury to the shooter.

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Handloader's Manual

FOREWORD

THE BASIC ELEMENTS OF HANDLOADING.

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The reasons for handloading ammunition may be summed up as (a) permitting one to obtain the greatest possible accuracy from his rifle, pistol or revolver and (b) providing one with an abundance of ammunition at small expense. If you have a firearm that you do not shoot as much as you would like to because of the expense, it will pay you to reload your fired cartridge cases.

Handloading is not a complicated procedure, nor does it require a large investment in loading tools. Any person of ordinary intelligence can, with a few simple tools and the instructions supplied by their manufacturer, load accurate and safe ammunition. Handloading is not recommended for the inmates of insane asylums nor for those who *should* be in such an institution.

The novice sometimes has the false impression that an extensive knowledge of ballistics is necessary in order to load good ammunition. This is perhaps fostered by reading books on handloading which contain a great deal of data that is of interest and use to the *experimenter* or to the person who wants to know "why," but it is by no means necessary to the man who merely wishes to reload good ammunition. To the reader who may have difficulty in separating the essentials from the non-essentials let it be stated here that reloading consists of replacing a fired primer with a new one and loading a proper powder charge and bullet into the case. One may be able to discourse for hours on all the subjects relating to the loading of ammunition but when it comes to actually reloading a cartridge he pokes out the fired primer and puts in a new one, loads a powder charge into the case and seats a new bullet—for that is about all anyone *can* do.

Of course, there are a few details which must be observed in assembling ammunition in order to obtain the best of accuracy, but they are very simple things and it is no more *work* to load a good cartridge than a *poor* one.

While economy is the motive that prompts most shooters to reload their fired cases, it is obvious that reloading would not be practical unless the resultant ammunition were of good accuracy. Indeed, the superiority of carefully hand-loaded ammunition has long been recognized. In justice to the manufacturer, it may be stated here that it is not uncommon for some lots of factory ammunition to be fully as accurate as anything the handloader can produce. However, when match ammunition is produced,

especially for long range shooting, the ammunition manufacturers practically hand load it. This is a slow and expensive procedure and such ammunition is often sold at a loss, the manufacturer depending largely upon the advertising benefits for his compensation.

To the person who knows nothing of handloading it may appear strange than an individual shooter without extensive knowledge of ammunition and with only a few simple and inexpensive tools can improve on the product of the manufacturer who has every facility at his disposal. The answer to this is not difficult. The very slowness with which hand-loading is done permits a minute 100% inspection of each and every operation by the person who has the most intimate personal interest in the result. Furthermore, the reloader can fit his ammunition perfectly to his own particular firearm. When ammunition is reloaded in large quantities by machine, the resultant product is no better than the average of new factory ammunition and is sometimes not as good. *Care* in handloading is of far more importance than *speed,* and the shooter who constantly bears this in mind will be rewarded by the superior accuracy of his ammunition.

Loading Tools.

The first requirement for handloading ammunition is a loading tool and such additional accessories that may be necessary to the purpose. It is not the purpose of this book to catalogue in detail all of the loading tools that are on the market nor to analyze or criticize any of them. Any attempt to do this is very likely to result in comments that are prejudicial to one or another of them, as they are all combination tools and compromises are necessary in order to make them perform all of the necessary operations and to produce them at reasonable prices. It is sufficient to say here that there is no loading tool in existence that will not reload good ammunition if it is used carefully and with a clear understanding of the results that must be accomplished.

Any person desiring to enter the ranks of the handloaders will do well to obtain and study the catalogues and hand-books of the loading manufacturers and to purchase the type of equipment which seems to suit his particular desires, as well as his pocketbook. Elaborate equipment is not necessary and this writer believes that the beginner should purchase the very minimum of equipment at the start, adding to it as his particular needs and experience dictate.

A little actual experience in reloading cartridges will be found more valuable than reading all the handbooks in creation, and the directions which accompany loading tools are sufficient to begin on. Without some experience as a foundation, the comments in handbooks are likely to prove confusing to the beginner, especially those comments that go into the more intricate details of handloading. Look upon books about this subject as correspondence courses on the subject of handloading. One would hardly expect to progress very far in the subjects' of mechanical drafting or electrical engineering without drawing instruments or electrical apparatus with which to work and for the same reason books should be used in connection with the loading tool. In short, the only real way to learn how to load ammunition is to load some ammunition.

The following firms manufacture loading cools suitable for the use of the individual handloader and in addition most of them manufacture or can supply powder measures, bullet moulds and other necessary handloading accessories. Modern Bond Company, Wilmington, Delaware. Belding and Mull, Philipsburg, Centre County, Penna. Lyman Gun Sight Corporation, Middlefield, Connecticut. Pacific Gun Sight Co., 355 Hayes St, San Francisco, Calif. Yankee Specialty Company, 851 E. 6th St., Erie, Penna.

The selection of a loading tool is not always easy for the novice, lacking, as he must, any real knowledge of hand-loading and often the information he gives the manufacturer in his initial inquiry is inadequate for the latter to make better than a general suggestion as to the equipment which will best suit his purpose. Any manufacturer can and will suggest proper loading equipment if given complete information, and the following facts should be included in the inquiry:—

1. The make, model and caliber of the arm you intend to load ammunition for. By “caliber” is meant the manufacturer's designation of the cartridge the arm shoots. For example, “a Cal. ·38 Colt revolver” or “a ·250/3000 Savage rifle” would be insufficient. In the first instance, “·38-caliber” means nothing, as there are many different ·38-caliber cartridges and the correct name of the particular cartridge as well as the model of the revolver should be given. In the latter example, the cartridge is specified plainly enough, but cartridge cases usually stretch more in the Model 99 Savage than in the Models 20 and 40 made by the same manufacturer and they therefore may require different treatment and different equipment in order to reload them satisfactorily.
2. You should also specify whether you wish to reload ammunition with cast bullets, or with factory metal jacketed bullets, or both, as in some cases this also has considerable bearing on the type of equipment necessary.
3. It will do no harm to mention the main purpose for which you intend to use your loaded ammunition; that is, whether for short or mid-range target shooting, small game or vermin hunting, long range military target shooting, or what.

If you will always give the manufacturer this information it will aid him materially in suggesting the particular items that you will need in order to best accomplish your purpose.

PART ONE

CARTRIDGE COMPONENTS

CHAPTER ONE

THE CARTRIDGE CASE.

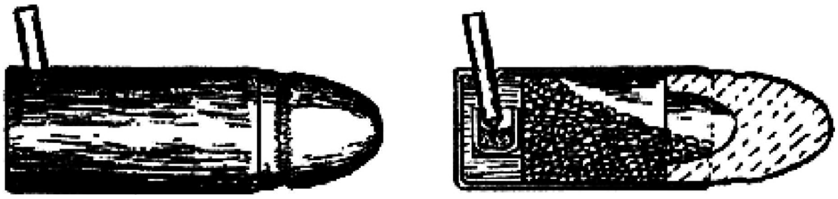
The cartridge case is the primary component with which we have to deal in reloading ammunition and its condition after firing, as well as its care, are of importance to the safety and accuracy of our reloaded ammunition. Early attempts to make breech loading arms were largely unsuccessful up to the time the cartridge case was invented, for despite attempts to seal the breech with carefully fitted

parts, gas would escape from there in close proximity to the shooter's face, a condition conducive neither to comfort, safety, good shooting or good ballistics. The brass cartridge case solved this difficulty because the thin walls of the case, pressed firmly against the chamber walls by the expanding gases, made a perfect "obturator" or gas seal and effectually prevented any escape of gas to the rear. THE CARTRIDGE CASE SHOULD ALWAYS BE THOUGHT OF AS A PART OF THE ARM IT IS FIRED IN and not merely as a convenient container for transporting charges and loading them into the gun.

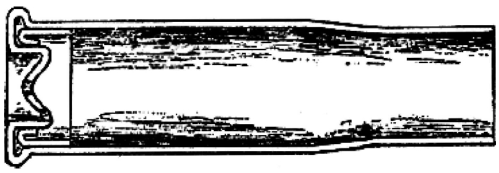
For a better understanding, of this function and the development of this important component, let us briefly look into its history. One of the first breech loaders that was considered as reasonably successful was the Sharps. This arm has a vertical sliding breech block which fits closely against the rear face of the barrel. It used a linen cartridge containing the bullet and powder, but was fired by a percussion cap. The cartridge, when inserted in the chamber, projected enough so that the sharp edge of the breech block sheared off the rear of the linen envelope in closing, leaving the powder exposed to the flash of the cap. When the arm was fired there was more or less escapage of gas to the rear, causing erosion of the metal surfaces and consequently a continual increase in the escape of gas.

Another early breech loader was the German Dreyse or "needle gun" used by the German Army in the Franco-Prussian War, This was a single shot, bolt action rifle using a fabric cartridge which was peculiar in that the primer was placed at the base of the bullet and was fired by a long, sharp needle that penetrated the powder charge. There was a considerable escapage of gas through the bolt of this rifle. The French picked the idea up and improved upon it in their Chassepot rifle by incorporating a rubber gasket or washer in the bolt which expanded and formed a gas seal under the pressure of the powder gasses, however the sulphur in the powder quickly hardened the rubber and made it ineffective.

Other noteworthy advances were the Boxer cartridge used in the British Snider rifle and the French Lefaucheux or "pin fire" cartridge. The former employed a rimmed case of more or less conventional form, having a body of coiled brass and a separate head of cast iron. The latter was designed like the sketch shown herein, having a self-contained firing pin that projected from the side of the base. Arms using this cartridge had a notch in the breech of the chamber to accommodate this pin, which was struck by the hammer and driven against the internal primer. The Lefaucheux cartridge was not particularly convenient to handle, transport or load and was dangerous if dropped.



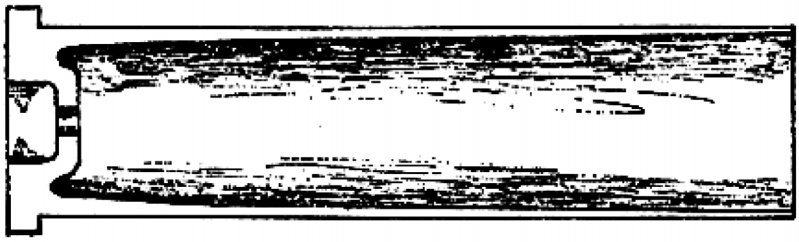
The Lefaucheux Cartridge.



The original folded head case.

The first one piece, drawn brass cartridges cases of the type with which we are familiar were made of thin brass with the heads or rims bent or folded, much as our present rim-fire cartridges are made today. The brass was so thin that it was usually necessary to employ a reinforcing band of brass inside the case, near the head, to support the strain at this point. These were the original and true "folded head" cases, but they could not be resized as the heads were too thin to stand driving out of a resizing die. This type of case has not been manufactured for many years and is not likely to be encountered now, except in obsolete cartridges of considerable age. Because these early cartridges were expensive, reloading was universal and most arms manufacturers supplied reloading tools for the users of their arms. Winchester, Remington and Smith & Wesson made their own, but Colt seems to have catalogued and supplied Ideal reloading tools to the users of their revolvers.

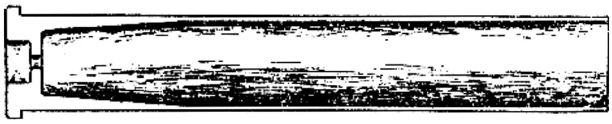
Naturally, the reloaders of the time were not satisfied with the thin, folded head type of cartridge case. The corrosion caused by the use of black powder quickly weakened the brass, the expansion of cases due to firing was severe and they could not be resized. There was, therefore, a universal demand for a stronger case that would overcome these objections, so the solid head type of case was developed. This type was drawn out in the form of a cup, the walls of which increased in thickness towards the bottom, this latter being the thickest part. This bottom, or base, was later mashed or cold forged to form the rim, while the primer pocket was bent or forced into the metal of the head, just as it was in the older folded head case. The difference in the primer pockets of these two types of case was practically in the thickness of the metal, and in both types the formation of the primer pocket created a raised hump on the inside of the head of the case. Strangely enough, this cartridge case that was once hailed with joy by reloaders; this case that came in boxes boldly labeled "solid head," and with directions that extolled their virtues for reloading purposes, are today known as "folded head" cases. The term "folded head" is not a correct one to apply to them, as a comparison of the cross sections of the different types of cases shown here will make it clear that their heads are not really folded at all. Nevertheless!, the term is in common use and throughout this book the term "folded head" will be used in referring to this type of cartridge case, unless explained to the contrary.



The original solid head case—today known as the folded head.

But this new case had its limitations also. It was satisfactory with black powder loads, which rarely developed pressures of more than 30,000 lbs. per square inch. When smokeless powder came into use and chamber pressures were increased up to 45,000 and even 50,000 lbs. per square inch, thicker and stronger case heads were necessary. During this period of transition the Ideal Everlasting case was brought out.

The Ideal Everlasting case was a drawn brass case with thick side walls, much thicker than commercial cases of the time, and with solid heads, as we employ the term today. That is, the rim and head of the case were one solid mass of metal, with the primer pocket forged or mashed into the brass, without indenting the interior of the case at all. Incidentally, these cases often had the primer pockets carefully reamed to size. The walls of Everlasting cases were too thick to permit crimping and they were only suitable for use in single shot rifles. They were expensive, but were practically "everlasting" when properly cleaned and cared for after firing. The illustration here shown is of a ·40/90 Ballard Everlasting case, it will serve to give an idea of the heavy structure of Everlasting cases, which were only made for straight or straight taper chambers, The thickness of these cases depended upon chamber and bullet diameters.

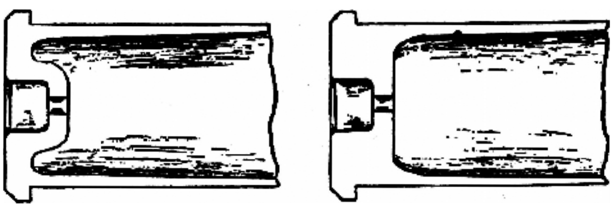


The Ideal Everlasting case. Modern solid head cases of today are made on this principle.

The use of solid head cases became general for all smokeless rifle cartridges developing high pressures. In recent years, with the development of the so-called high speed revolver cartridges, the use of solid head cases has been extended to some revolver calibers and the folded head type is fast disappearing.

In this rather sketchy description of the development of the cartridge case, there has been no purpose other than to show that this component has been improved and strengthened from time to time with the object of holding in the powder gasses, *which is the primary function of a cartridge case.* The chamber and bolt or breech block of an arm are insufficient to do this and these parts only act as supports for the case, which is in reality a part of the arm it is fired in and I repeat that it is important that the handloader always view the cartridge case in this light.

How Cartridge Cases Are Made. Cases are still made of brass as this material can be easily obtained, it has the necessary strength if properly worked and it can be fabricated more cheaply than some other metals. Steel can and has been manufactured into cartridge cases but while steel is a much cheaper material than brass, it is far more expensive to fabricate and the high manufacturing cost much more than offsets any saving in the cost of the raw material. Incidentally, the use of steel cartridge cases would greatly increase the strength and safety of our present rifles, but is unlikely that this generation will see any steel cases used for commercial ammunition, unless some cheaper method of manufacture than we have at present is devised.



FOLDED HEAD SOLID HEAD

Modern styles in case manufacture.

A detailed description of cartridge case manufacture would be of little practical use to the reloader but some understanding of the process and of the physical nature of the finished case is necessary in order to understand the changes that take place when the case is subjected to the strain of firing.

The general process consists in blanking out discs from strip brass and forming the discs into cups. These cups are forced or drawn through successive dies which elongate them, at the same time reducing their thickness and diameter. The heads and primer pockets are formed by cold forging the bases of the cups and the rims or extractor grooves are turned. The cases are given the proper taper or bottle-neck form by forcing one or more dies of the proper shape over them, after which they are trimmed to the correct length.

The severe stresses and strains that cartridge cases are subjected to when fired, makes it necessary to use only brass of the highest quality in their manufacture for, it must be remembered, the cartridge case is part of the arm it is fired in and the safety of the arm and

the shooter depend largely upon the strength of the case. The usual alloy used is about 70% of copper to 30% of spelter (zinc) and every care is taken to exclude impurities and other metals. In foundry parlance, "cartridge brass." means just about the finest brass that it is possible to procure.

Brass, when etched and viewed under a microscope, appears as a crystalline structure. The size and form of the crystals depends upon two things; cold work and annealing. Working, that is, drawing, bending or compressing brass while it is cold, hardens it by stretching or compressing the crystals, while annealing softens it, causing the crystals to re-form. The greater the heat and the longer its duration, the larger the crystals become.

In manufacturing cases, it is necessary to anneal the cups between each drawing operation and also before they are tapered or finish-formed. These anneals are carefully worked out with relation to the amount of cold work to be performed after them, so that the finished case will have the proper degree of hardness. The case must not be too hard or it will rupture when fired. On the other hand, if it is too soft it may give way when fired, ruining the rifle and possibly the shooter as well. All parts of the case are not of the same degree of hardness. In general, the head is of a tough, coarse structure, with the side walls gradually increasing in hardness towards the mouth of the case. The physical characteristics of different calibers are not the same, as each one presents its own metallurgical problems. However, what we are interested in knowing here is, that a cartridge case has a crystalline formation, that it is carefully made to give it the proper strength and that both of these factors *can* be changed when the cartridge case is fired, although they normally are not.

The Cartridge Case and Its Chamber.

As the cartridge case is a part of the arm it is fired in, it is necessary to understand and to give some consideration to the arm, in order to understand the changes that take place in the case when a cartridge is fired. This change may be, and normally is, negligible, which has given rise to the general statement that cartridge cases are just as good and serviceable after firing as they were before. This statement is substantially correct, but not literally so, because some change *does* take place during the firing. It is perfectly obvious that if no change took place the first time the case were fired there would be no change the second time and so on *ad infinitum.* The kind and amount of change depends principally upon four things; the relation of the size and shape of the case to the chamber it is fired in, the pressure developed within it, the thickness and temper or hardness of the brass itself, and the products of combustion that are left in the case after firing. Any of these things or any combination of them can, under some circumstances, render a cartridge unsafe for reloading . . . but they usually don't.

Relation of Cartridge to Chamber. The chamber of an arm is the recess provided in the rear of the barrel or cylinder to receive the cartridge. As cartridge cases are made of springy brass, it is impossible to make them all exactly alike and the cases of each caliber will, if measured very carefully at all points, be found to differ slightly. This variation in dimensions will not only be found in different makes of cartridges of the same caliber but are present in cartridges of the same make and even among those from one lot produced on the same machines. The uniformity in dimensions of all calibers of our American ammunition is truly remarkable and the little differences referred to here are what are known as manufacturing tolerances, or the slight differences that can be permitted without affecting the serviceability of the finished product. The smallest cartridge of any given caliber is known as a minimum cartridge, while the largest permissible cartridge is called a maximum cartridge. The differences in any of the dimensions between the two will ordinarily not exceed a few thousandths of an inch.

Chambers and Chambering. The chamber of a rifle, or the recess in the rear end of the barrel into which the cartridge enters, has a great deal to do with the accuracy of the arm. The reaming of chambers is one of the exacting operations of arms manufacture, calling for the utmost skill and care. While it is possible, with modern machine tools, to chamber arms accurately and at the same time quite rapidly, nevertheless the work must be done by men who have had long experience with it. Perhaps it can best be said that the work of chambering *should* be done by men of long experience, for we sometimes encounter chambers that would reflect discredit on the village blacksmith. Naturally, the price of the rifle has something to do with this and a cheap arm that is hacked out to sell at a low price cannot be expected to have the careful and painstaking workmanship that is put into the production of a more expensive one.

Chambers are made after the barrels are reamed and rifled, and they are formed by a series of reaming operations. The breech of the barrel is drilled out to remove excess metal, after which one or more roughing reamers are run into it to the proper depth, to bring the chamber approximately to shape. These first operations leave the chamber too small at all points and do not go in to the full depth of the finished chamber. The character of the surface of the chamber is of no importance at this stage.

The chamber is brought to its finished size and shape by the use of additional reamers, each one of which removes only a small amount of metal. The difference between the finishing reamer and the one that precedes it is often little more than a thousandth of an inch. This final reaming must be done with great care and with a carefully stoned reamer, in order to give that very smooth surface to the chamber which is so necessary to the easy extraction of fired cases.

So called straight chambers, like those for revolver cartridges, are the easiest to make, while bottle-neck chambers for rimless cartridges offer the most difficulty; especially where the type of arm requires that the barrel be finished chambered before it is assembled to the receiver, as in lever action rifles. Barrels for bolt action rifles, as a rule, have the chambers left a few thousandths of an inch too short. After the barrel is assembled to the receiver, the chamber is reamed by hand to bring it to the proper depth with relation to the bolt, so that the head space will be correct. This head space reaming is confined almost entirely to chambers taking rimless cartridges and where the design of the rifle permits it, it can be done more precisely *after* the barrel is fitted to the receiver than before.

Chambering reamers, like all others, must be sharpened from time to time and this sharpening or stoning gradually reduces their size and, to a certain extent their shape until they can no longer be used. A finish reamer, which gives the chamber its final size and form, when worn out, is usually reduced in size and used on the next preceding operation, but between the time it is first put in use and the time it is worn out there is a difference in the sizes of the chambers cut by it. Slight differences will exist without any change in the reamer itself, so that the production of two or more chambers that are *exactly* alike is a matter of chance. In addition, no two

reamers are *exactly* alike, except by chance and different manufacturers may have different ideas as to the chamber form and taper they wish to use, which is influenced by the nature of the arm being made. Ordinarily, the greater the taper of the chamber, the easier the extraction of fired cartridge cases will be and a little more taper is necessary in the chamber of an arm having a limited amount of power or leverage for extracting, than in a bolt action rifle having a powerful camming action for the extraction of fired cases.

It is not the intention to go into the details and problems of chambering here, but the reloader should understand that chambers of the same caliber differ considerably between makes and models of arms and also, to a lesser extent, in arms of the same make and model. It should also be understood that the mere fact that a chamber appears to be large and permits a visible expansion of the cases fired in it, does not mean that the arm is poorly chambered. Such a chamber may be necessary to the proper functioning of that particular arm and is to be distinguished from a poor chamber.

Head Space.

While the chamber proper supports the walls of the cartridge case against the severe stresses incident to firing the cartridge, the total over-all length of the chamber, in relation to its cartridge, is governed by the bolt or breech block that closes it and supports the head of the cartridge case. In other words, the location of the face of the bolt or breech block, governs the head space of the arm.

The head space of an arm is the distance from the surface of the chamber or barrel, that positions or prevents further forward movement of the cartridge into the chamber, to the face of the bolt or breech block when the latter is fully back against the shoulder that supports it. Rimmed cases are positioned by the rim which hears against the rear face of the barrel or, in the case of revolvers, against the rear surface of the cylinder.

Rimless cases present a special problem for, as their name indicates, they have no rims to act as a stop against their forward movement into the chamber. The shoulder of the case serves this purpose, therefore the head space of a rifle for a rimless cartridge is the distance from the beginning of the shoulder of the chamber to the face of the bolt. The measurement of head space is taken from the beginning of the shoulder, because, the angle of the chamber shoulder and the angle of the shoulder of the cartridge case are not the same, the former being the less abrupt of the two.

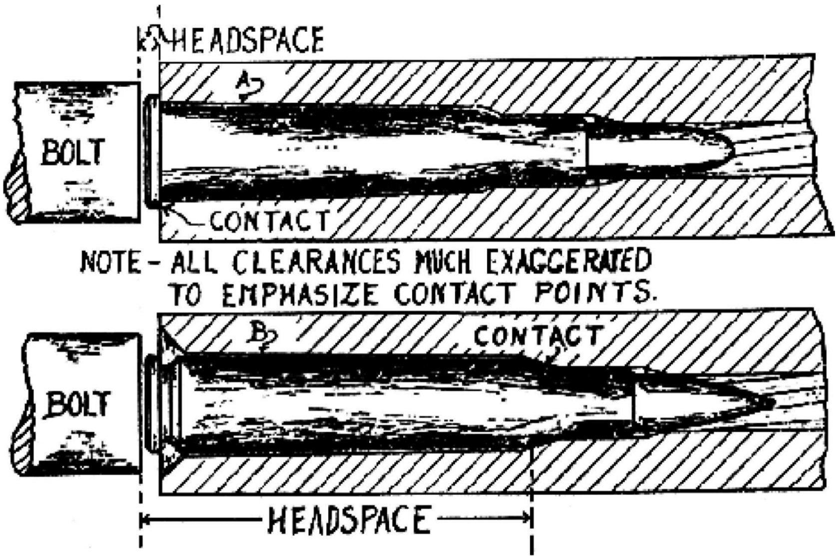
There is usually a small amount of play between the face of the bolt and the rear of a rimmed cartridge, when the latter is in the chamber. The clearance must be sufficient to take cases of maximum rim dimension, plus a small allowance for the occasional thick rimmed case that will always get by the inspectors once in a while. Consequently, with cases of a minimum rim thickness there will be several thousandths of an inch clearance between the head of the case and the bolt. The rim of the case, being of solid metal, cannot be compressed and if the fitting of the bolt were too close, it would frequently be impossible to close it on the cartridge.

The situation is different with rimless cases. The head space may be greater than the shoulder to head length of the cartridge but it may also be, and frequently is, less. The bolt will close on a rimless case that is longer than its chamber, because there is an opportunity for the shoulder to give slightly under the pressure of the bolt, or the case walls may spring out slightly, or both. Furthermore, as a new cartridge is always smaller than its chamber, its forward movement into the chamber is not stopped precisely at the beginning of the chamber shoulder, For these reasons, the head-to-shoulder length of the cartridge may be greater than the corresponding length of the chamber and still have the arm function satisfactorily.

When, due to the set-back or wear of the locking surfaces of a bolt or breech block, the head space exceeds the maximum limit set by the manufacturer of the arm, the arm is said to have excess head space. Many people are under the impression that "excess head space" indicates a dangerous condition, just because a few arms having this condition *to an abnormal degree* have been known to blow up. This idea is fallacious, for it is obvious that no reputable manufacturer is going to put out arms that are on the ragged edge of being dangerous. The maximum limits of head space for all rifles are established so as to leave a very liberal margin for any increase that is likely to occur through ordinary usage.

Influence of Head Space on the Case. The diagram on this page shows the points from which head space measurements are taken for both rimmed and rimless cartridges. It will be observed that most of the solid head of the rimmed case is well within the chamber, while only a small part of the solid head of the rimless case enters the chamber. It will also be noted that the necks of the cases (new cases) do not reach the forward end of the chambers. This clearance is provided to insure proper functioning of the arm, even if an occasional case of extra length is loaded into the chamber. It also provides for smooth operation in spite of any minor fouling of the chamber.

When a cartridge is fired and the burning powder begins to build up pressure in the chamber, the thin walls of the case expand, gripping the walls of the chamber. If there be any excess head space, the blow of the firing pin will usually drive the cartridge forward, leaving a space between the face of the bolt and the cartridge head. With the walls of the case gripping the chamber walls, the head of the case will be driven back against the bolt. This will stretch the brass to a greater or lesser extent, depending upon the distance that the head moves. The point of strain is usually at about the location of A and B on the sketch, although it may occur further forward. This stretching will thin down the brass in the walls of the case and weaken it and if the excess head space or the movement of the case head to the rear be great enough, a complete head separation will occur. When there is a partial or complete separation of the head of a case at high pressure, there is a possibility of injury to the arm, the shooter, or both, but often there is enough of the side wall left to act as an obturator and stop most of the gas. This is especially true of the rimmed type of case, which has practically all of the solid head within the chamber. Such gas as may escape to the rear is deflected by the rim of the case, so the separation of the head of a rimmed case seldom results in injury of any kind to the arm or to the shooter.



With rimless cases, the situation is not so good. The point where the head usually separates is so close to the end of the chamber that the likelihood of gas escaping to the rear is much greater than with the rimmed case. In addition, the rimless case has no rim to deflect this gas, which, in bolt action rifles, will come back through the bolt, causing eye burns or perhaps more serious injury, accompanied by the wrecking of the rifle. This can also happen with some lever action rifles, except that one is relatively safe from eye burns with rifles having solid or completely enclosed actions. However, such rifles are harder to head space accurately and when a head separation is accompanied by the escapage of a considerable amount of gas *at high pressure,* the shooter is in for trouble regardless of the kind of rifle he is using, for *no arm is safer than the cartridge cases used in it.*

Assuming that the head space is not great enough to cause a head separation, the cartridge case will be stretched and expanded to fit the chamber perfectly. If it is not resized or if it is only resized at the neck, the head will be in perfect contact with the bolt the next time it is fired and there will be little or no further stretching of the case. Naturally, excess head space will cause the case to lengthen, will reduce the thickness of the side walls near the head and there is no way of returning the strained part of the case to its original condition. If the case is resized full length, it will merely set the shoulder back the same distance that the case stretched and will give the case the same clearance between the head and the bolt that it had originally. When fired again, the head will set back again and the side wall will be further weakened or may even tear apart. Mercuric primers will aggravate this condition, as the mercury will penetrate the strained brass rapidly and render it brittle and useless, even at low pressures.

If you have a rifle in which head separations occur with factory loaded ammunition, it is a pretty good indication that the arm has an excessive and dangerous amount of head space and you should communicate at once with the manufacturer regarding its repair or adjustment.

Cartridge cases loaded with high pressure loads will lengthen even though the bolt or breech block be in firm contact with the head of the case. The brass is forced *forward* and while this does not ordinarily result in any weakening of the case, there are exceptions to this general rule. It may be a matter of chance or it may be due to soft spots in the case but occasionally a case wall will be weakened from this cause. The strain, if any, may occur anywhere from the shoulder back to the head of the case. A few years ago, the writer conducted a series of experiments for the Cuban Army, in order to determine the approximate rate of elongation of the ·30-06 cartridge case. Some ·30-06 ammunition was fired in a rifle having the minimum head space of 1·940 inches, then ammunition from the same lot was also fired in another rifle having the maximum head space of 1·946 inches. The cartridge cases from each rifle were kept separate and were reloaded with the Model 1906 bullet and a powder charge developing 2,700 f.s. muzzle velocity, at a pressure of 49,000 lbs. per square inch. After each firing, the cases (each one stamped with an identifying mark) were measured for increases in length and were resized so the body length was 1·9487 inch.

The cases fired in the rifle having minimum head space showed an average elongation of ·027 inch after four reloadings plus the original firing, while those fired in the rifle with maximum head space showed an average elongation of ·035 inch with the same amount of firing. The only case which showed any localized weakening was thin as paper *at the shoulder,* but this case might have been thin at this point originally. Practically all of the cases were increased in length so their mouths were jammed into the forward end of the chamber after the fourth reloading but, with the one exception mentioned, all could have been made serviceable again by trimming back to their original length.

Cases will elongate when reloaded with full charges. If this elongation prevents the free entrance of the case into the chamber, the mouth of the case can, without harm, be filed or reamed enough to shorten it slightly. Reamed is preferable.

Some rifles have bolts or fairly long breech blocks that lock at the rear end, instead of at the front immediately back of the cartridge. Such arms, while perfectly safe, permit cases to stretch noticeably when fired with high pressure loads. The bolts, being supported at the rear, have a tendency to spring or buckle slightly under the thrust of the cartridge head and it is not infrequent that a high power cartridge case from such an arm will fail to enter its own chamber again, at least it will not go in far enough to permit the action to be closed. This stretching produces a condition similar to that caused by the presence of excess head space and where this condition is encountered, it is advisable not to reload the fired cases with full loads. The cases must be entirely resized to be used and with full loads the stretching will be repeated, which may lead to head separations.

Expansion of Cartridge Cases. It has been pointed out that cartridge cases of the same caliber will vary slightly in their dimensions and that chambers of the same caliber will also vary. These variations are remarkably small but they do exist. It is obvious that the smallest chamber of any given caliber must be large enough to take the largest cartridge made for it and, conversely, in manufacturing the ammunition, the maximum cartridge must be kept *within* the size of a minimum chamber of that caliber. When a maximum cartridge is put into a minimum chamber there will be a small clearance between the two, that is, the unfired cartridge will enter and extract from the chamber freely. However, when a minimum cartridge is put into the same chamber the clearance is greater and, if we make the same comparison with a maximum chamber it is easily seen that the clearance between cartridge and chamber is still further increased.

When a cartridge is fired, the internal gas pressure forces the walls of the case firmly against the chamber walls and after the bullet has left the bore and the pressure drops to zero, the walls of the case do not go back to their original position. The case will have taken on a permanent set and expanded to perfectly fit the particular chamber it was fired in. The springy nature of cartridge cases cause them to spring back slightly after the pressure drops so that they may be extracted easily and in most instances they will re-enter the same chamber without difficulty. As already explained, if there is spring or set back in the bolt or breech block, the case may elongate in a way that will prevent its re-entering the same chamber again without resizing, but elongation and lateral expansion are two different things and they affect the cartridge case differently.

In any normal commercial or military chamber the expansion that takes place in the cartridge case is unimportant, except that it is *improved* in as much as it is now a "tailor made" case, fitting its particular chamber more perfectly than it could be made to fit by any other means. If it has not been weakened by stretching, the case may be reloaded with charges approximating the original factory charge, or at least the original factory pressure. On the other hand, if either the stretching or the expansion is excessive at any point; the case should be used only for reduced loads, or discarded if the condition is bad enough.

Split Necks. Excessive expansion at the neck may cause a split or opening to occur at that point. Occasionally, and particularly in old ammunition, cartridges may be found with the necks split, due to season cracking. These split necks may be visible or they may split under the stress of firing. There is no danger connected with the shooting of cartridges having split necks, but their continued use is likely to cause some erosion of the chamber neck which may lead to extraction difficulties. If such ammunition is used, a loaded cartridge should *never* be extracted from the chamber without making sure that the bullet does not remain in the barrel. Should the bullet remain in the barrel, it might be possible to seat another cartridge having a loose bullet behind the first one. Forcing the second bullet back onto the powder charge would increase the loading density and cause a rise in pressure, to say nothing of the great increase in pressure that would result from the weight and resistance offered by two bullets. Under such circumstances, if the arm were discharged, the barrel would be ruined and the pressure might be sufficient to cause the cartridge case to give way at the head, wrecking rifle. The usual effect of firing two bullets at the same time is to ring or bulge the barrel. The rear bullet starts out at a greater velocity than the forward one. The resistance offered by the forward bullet causes the point of the last and the base of the first bullet to expand violently at some point along the barrel and the radial pressure is sufficient to expand the steel outward. This makes a visible, dark ring in the barrel and may cause a bulge on the outside. Occasionally a barrel will split lengthwise from this cause. Lead bullets can make just as nice rings in a barrel as jacketed bullets, and high pressures or velocities are not necessary to do it either. The lowly ·22 rim fire cartridge can ring a barrel beautifully, if two bullets are fired at one time. Incidentally, ringing a barrel in this way will not affect its accuracy, at least, this writer has ringed a few barrels and has shot quite a few others that were ringed and has never observed any loss in accuracy from this cause. But, as far as cartridges with split necks are concerned, by far the best policy is to not shoot such cartridges. The bullets and the powder from them can be salvaged and loaded into good cases with very little effort and expense.

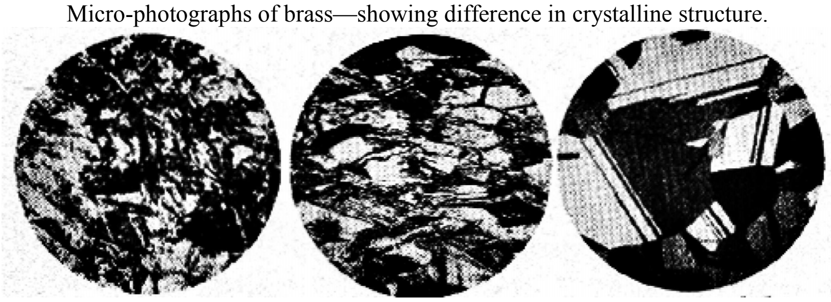
Season Cracking. This condition arises from internal stresses in the brass itself. If brass is too hard it may crack spontaneously in time, especially in hot climates or if subjected to corrosive gasses, also long continued strain of any kind may cause it. Season cracking is not a condition that occurs only in cartridge cases but is more or less common to all drawn brass articles. The condition is most frequently encountered in the form of split necks in ·30-06 ammunition manufactured during the World War. This ammunition was made hurriedly and with the belief that it would be used within a relatively short period of time. The necks of most of the cases were quite hard and under the strain imposed on them by holding the bullets under tension, the necks were apt to crack after a time. Since the war, the necks of practically all cases of rifle ammunition have been subjected to an additional annealing process that relieves the internal stresses, without rendering the brass too soft to hold the bullets properly. This makes the case necks better able to withstand the repeated reducing and expanding that is often necessary to properly reload them. Season cracking in small arms ammunition is practically a thing of the past and is only mentioned here as being of casual interest.

Body of the Case. Practically everything that has been said above with regard to the expansion of the necks of cartridge cases applies to the expansion of the body of the case as well. If the case is of the straight or cylindrical type, the body and neck are continuous and in this type the term "neck" is applied to that part of the case that is normally occupied by the bullet. In a straight taper case, such as the ·32-40, ·38-55, 45-90, etc., there is no definite line of demarcation between the cylindrical neck that holds the bullet and the tapered body. The distinction is very definite in the bottle-neck case, but in referring to the "body" we mean that part of the case between the neck or shoulder and the head, or the part of the case that contains the powder charge.

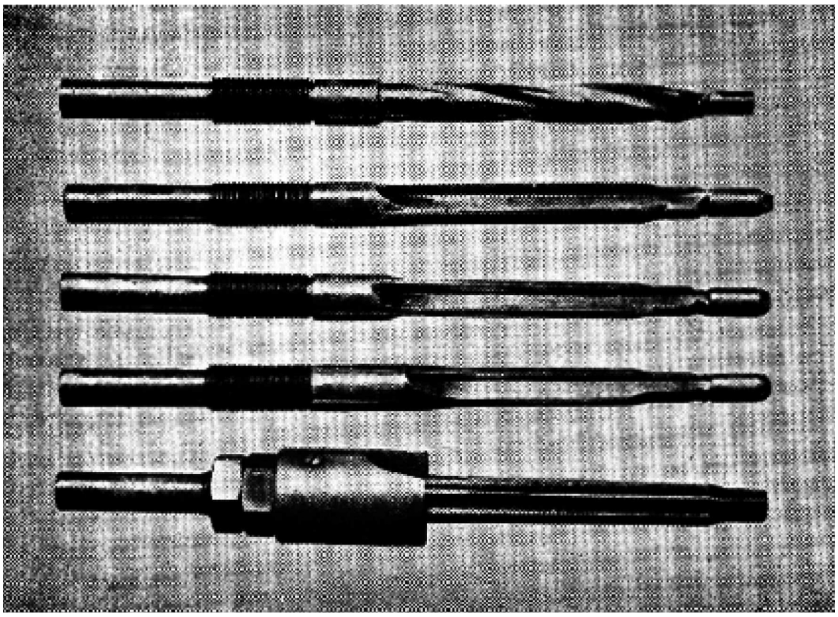
The degree of expansion of the body usually determines whether the case must be completely resized before reloading or not. The resistance offered by an excessively expanded neck is not of itself sufficient to offer difficulty in extracting the case from the chamber. All cases are not of the same degree of hardness or "springiness". The product of any one manufacturer will be found to run quite uniform, but there is often a considerable difference in the cases of different makes. Soft cases will not spring back from the chamber walls quite as much as harder cases and if soft cases are reloaded with full charges they are apt, after one or more reloadings, to be not only difficult to extract but also difficult to re-enter in the chamber in which they were fired. The remedy is to resize them in a suitable die and in doing this it is a good rule to only resize them enough to permit their entering the chamber easily. The complete resizing of cases should be avoided wherever possible, for reasons that will be explained later.

Splits or ruptures may occur in the bodies of cartridge cases; splits from excessive expansion, hard brass, defects in the brass or a combination of these things. Ruptures in the bodies of cases (except near the heads) are usually due to manufacturing defects and are of rare occurrence. Neither of these defects will cause injury to the arm or the shooter, provided that the break does not occur close to the head. The body of the case is, "just the part in between." The relation of the case neck to the neck of the chamber is of importance to accuracy as will be explained later, while the head; and the body for a short distance in front of it, takes much of the stress of firing and is important from a safety standpoint. The body just connects these, two parts together and no harm is likely to occur if it splits.

Micro-photographs of brass—showing difference in crystalline structure.

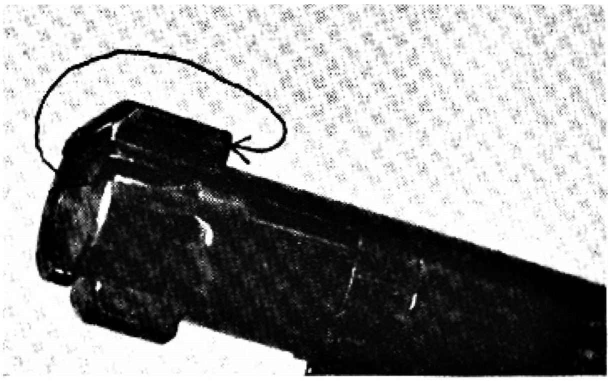


Hard Worked Partially annealed Fully annealed

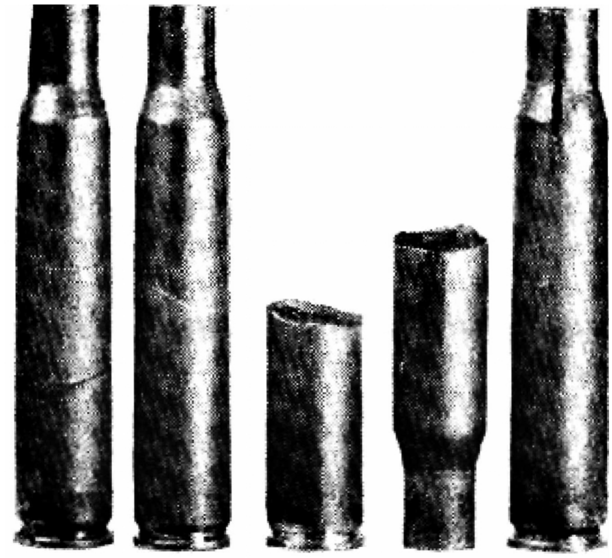


A Set of Machine Gun Chambering Reamers.

PLATE I.

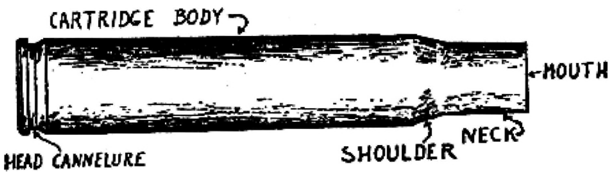


The distance from the face to the rear of the locking lugs is the most important dimension on a rifle bolt and is held very close.



Split and ruptured cartridge cases.

PLATE II.



The Cartridge Case.

Cartridge Case Head. In referring to this part of the case, it is intended to include that part of the body just in front of it where the side walls are thickest. Being the safety end of the cartridge, this part is worthy of the special attention of the reloader. In addition to scaling in the gasses, it contains the primer pocket and flash hole, or vent, and it is the part by which the case is extracted from the chamber. If a rimmed case, the rim serves to position the case in the chamber and affords a solid support to the blow of the firing pin, a more solid and satisfactory support, by the way, than the springy shoulder of the rimless case. Heads may be of the solid or the so called folded head types, the former predominate in present day ammunition, the latter being principally confined to revolver cartridge cases. Even in the latter there is a gradual swing toward the solid type of head, made necessary by the high speed loads with which some revolver cartridges are now being loaded. These loads develop pressures above the 15,000 lb, limit that is the accepted maximum for use in folded head cases and it is quite probable that in a few years time the folded bead case will become a thing of the past.

The thickness of solid heads will run uniform in any one lot of ammunition and generally in one make of a given caliber, but a considerable difference in the thickness of the heads, as wells as in the thickness and taper of the side walls, may be found in different makes of the same caliber.

As the *outside* dimensions of these cartridges must be kept the same, within close manufacturing tolerances, any increase in the thickness of the head or the side walls will result in a decrease in the volume of the cases. If two cases having different volumes are loaded with the same powder charges and bullets, the case with the least capacity will develop the higher pressure. With reduced or normal full charge loads, such a condition is not likely to be dangerous, but it might easily be a serious factor with maximum loads.

It has already been explained that chambers have a greater taper than the cartridges which go into them, in order to permit easy extraction, and that the taper varies in different types of arms of the same caliber. This sometimes results in a rather loose fit between cartridge and chamber at the head and permits a severe expansion of the case at the junction of its side walls and the head. This causes the metal in the solid head to tear apart for a short distance. If the case is resized completely, the torn metal will be pressed together, but the torn surfaces will not unite into a homogeneous structure. Upon firing the case again with a full or approximately a full charge, the same amount of expansion will take place once more and the violence of the expansion will cause the brass to tear further. The illustration on Plate III shows such a condition. This is a photograph of a factory cartridge after the first firing and the dotted lines show the approximate form of, and the condition as it would apply to a rimless case. This condition is no joke and is worthy of the consideration of every careful reloader. The only practicable method of determining whether or not this condition exists is to examine the fired cases for expansion near the head and if the expansion appeared to be excessive, to section a few cases and look for torn metal in their solid heads. The correct method for doing this is described on page 16.

If heads tear in this way and the cases are *not* completely resized, when they are reloaded and fired the case will be in close contact with the chamber walls because of the expansion that already has taken place, consequently there will be very little or no further tearing of the brass in the solid head. Nevertheless, cartridge cases that expand excessively near the heads should not be reloaded with anything except reduced loads.

Primer pockets and vents, being closely related to the performance of primers, will be discussed under the subject of “primers” in Chapter 2.

The Care of Fired Cartridge Cases.

If cartridge cases that have been fired with smokeless powder are to be kept for some time before they are reloaded, they should be stored in a dry place but otherwise they require no particular care. If the necks of the cases are smoked up a little, this fouling may be wiped off with a cloth, provided the wiping is done within a short time after they are fired. While this fouling is easily removed when fresh, if allowed to remain for some time it will result in oxidization of the brass. This oxidization will do no harm except that if the brass be left under strain, it will accelerate any tendency to season crack. If cases are kept in a damp place they will have a tendency to corrode, the corrosion being noticeable as discolored patches having a hard granular feel to the fingernail in the early stages. As the corrosion progresses verdigris will form. Cases showing any considerable corrosion should be discarded.

Hand books on reloading ammunition have usually carried a description of one or more methods of washing cartridge cases so as to make them practically as bright and clean as when new. In the opinion of this writer, the washing of cartridge cases that have been fired with smokeless powder is not only unnecessary but inadvisable, except under special circumstances. Cases fired with black powder *must* be washed to prevent them from corroding. Black powder leaves a heavy deposit of fouling in the case and this fouling will gather dampness rapidly. The sulphur in the fouling, when in the presence of moisture, attacks the brass rapidly, causing verdigris to form and weakening the case materially.

If cartridge cases that have been fired with smokeless powder are to be reloaded for military use, or for issue to men who know but little of ammunition and are apt to judge it by appearance as well as its performance, or if the ammunition is to be stored for a long period of time, there is some justification for cleaning the cases so they will have a new appearance. Otherwise, washing cases is an unnecessary labor amounting to a waste of time. The reason for suggesting that cases be not washed is because most of the factory ammunition being turned out today is loaded with primers containing fulminate of mercury. The mercury left in the case by the fired primer attacks the brass more or less, depending upon circumstances that will be touched upon later, and renders the brass brittle and unable to withstand the strain of further firing. The use of any solution, whether acid or alkaline, on cases that have been fired with mercuric primers will hasten the action of the mercury and cause it to penetrate the brass deeper than it would have otherwise. Even plain water, in combination with the products of combustion in the cases, will accelerate this action. Hence the suggestion that cases fired with smokeless powder should be stored in a dry place and that they should not be washed or chemically cleaned, except under unusual circumstances.

Washing Cartridge Cases.

It may seem a bit out of place to suggest methods of washing or cleaning fired cartridge cases immediately after advising against the practice, but the reader should bear in mind that the one serious objection to the washing of cases lies in the possibility of their having been fired with mercuric primers. If a case has *never* been fired with a mercuric primer, there is no danger attached to washing or cleaning it with any kind of a solution. Such cleaning may be entirely unnecessary, but it will not harm the cases if they have *never* been fired with a mercuric primer. Please excuse the emphasis on that word “never” but the writer has seen too many instances where reloaders only give consideration to the type of primer which they themselves use in reloading their ammunition, without taking into account the primer with which the ammunition was originally loaded at the factory. Most of the factory ammunition being produced today is loaded with mercuric primers and one manufacturer in particular who has been loading his ammunition with non-mercuric primers is slowly swinging back to the use of mercuric primers. Their reasons for using fulminate of mercury will be explained under the subject of “Primers.”

The best time to clean cartridge cases is as soon as possible after they have been fired, as the fouling is then soft and has not had time to corrode the brass even superficially. If cleaned promptly, the cases will come out bright with less effort and with a shorter immersion in the cleaning fluid.

Cases fired with black powder should be de-capped and dropped into a jar or can of water. The water will soften the fouling and facilitate its removal. If the cases are of a shape that will permit their inside to be easily reached with a swab on the end of a stick, they may be wiped out after they have soaked for a while. The primer pockets can be cleaned with a bit of cloth over the end of a wooden match stick. The best and easiest way to clean out black powder fouling from a lot of cases at one time is to boil them in soapy water, to which a small amount of baking or washing soda has been added. For a soap solution, any kind of soap or soap flakes may be used, including “Gold Dust” or “Oakite” Oakite is not really a soap but is a good cleaner. It is hard on the hands and should be used sparingly, as directed on the box. Treating the cases in this way will remove the heavy deposit of fouling from them, but may leave them dark and discolored, this will do no harm. Methods for brightening them will be given a little further on.

The fouling left by smokeless powder, while much less in volume than black powder fouling, is much more tenacious and more difficult to remove. To do a good and thorough job, the method that has been published for years in the Ideal Handbook is probably the best and it is repeated here briefly for the convenience of the reader.

Two one quart jars are required for the chemical solutions and two jars or other containers for clear water, preferably running water. In jar No. 1, dissolve *2* ounces of potassium bichromate and add 2 ounces of sulphuric acid, pouring the acid in slowly while stirring the solution. In the other jar, dissolve one quarter pound of sodium cyanide. Potassium cyanide may also be used but is more expensive. Both sodium and potassium cyanides are deadly poison and should be kept out of and away from containers in which food stuffs are to be prepared or preserved. The solutions in both of the jars are poisonous for that matter, furthermore if mixed they will give off poisonous fumes, so it is best to work with them where there is a good circulation of air.

The proper arrangement of the jars for working is as follows; jar No. 1—clear water—jar No. *2*—then another container of clear water.

To clean the cases, bend a piece of brass or copper wire a foot or more in length into the form of a narrow U. Then bend up the ends of the wire to form two hooks, on which the cases may be hung. Hang two cases on the hooks and dip them in solution No. 1 for a few seconds. Then remove them, rinse them thoroughly in clear water after which they should be immersed in the cyanide solution until they are clean and bright. This should require only a few seconds also but if the cases do not brighten up quickly, they should be rinsed thoroughly in the fourth container of clear water and the entire process repeated. The process of rinsing is important and if

running water is not available, the water in the two rinsing jars should be changed frequently to avoid carrying any of the chemical solutions from one jar to the other.

Another way to brighten cases and to remove corrosion, and one that is not only good but is convenient and as old as the hills, is to immerse the cases in vinegar. This is especially good for brightening cases that have had black powder fouling removed from them, as described previously. Vinegar will not remove smokeless powder fouling as well as the acid and cyanide solutions, but it will remove a lot of it and if the cases are cylindrical, or of a shape that will permit of their being wiped out with a mop or a bristle brush, a very good job of cleaning out smokeless powder fouling can be done as the vinegar will soften and loosen the fouling in a few minutes, without injuring the cases in any way. Vinegar has the advantage of being easily obtainable anywhere, it is not poisonous, and its storage and disposition offers no problem, even where space is limited or there are children around. The particular kind of vinegar is not important; it may be old fashioned cider vinegar, synthetic vinegar, even the juice drained off from pickle bottles will work.

Possibly this pickle juice idea will stand some elaboration. The whole answer to this cleaning with vinegar is *acetic acid.* Cider vinegar and, presumably, the synthetic vinegars also, contain about 6% of acetic acid. It is this acetic acid which softens the powder fouling so that it may be wiped out easily with a rag. As to whether "pickle juice" will do the trick or not depends upon the amount of acetic acid (if any) that is present in it.

Acetic acid comes in different strengths, a solution of around 28-36% being used extensively in photographic work. The full strength acid is 99% pure and is strong enough to attack the brass of a cartridge case actively, a piece of a case put into a test tube with the full strength acid will cause the solution to turn blue in a very few minutes. A 10% solution is amply strong for cleaning cases, but bear in mind two things: That the solution only softens the fouling but does not remove it and, that in common with any other solution, acetic acid will promote the penetration of mercury into cases that have been fired with mercuric primers. However, it is a fine solution to use for wiping the outsides or necks of cases clean, where you want them to look like new, factory "hulls."

Drying of Cases. Regardless of the method used for cleaning cases, they must be rinsed thoroughly and dried promptly, as otherwise they may corrode. Should any interruption interfere with the drying of cases immediately after they are cleaned, leave them immersed in clear water to keep the air away until they can be dried properly.

If the cases can be spread out in the hot sun to dry, boil them in clear water, dump them into a colander, then shake them well and vigorously to remove the excess water. Then spread them out in the sun to dry. The primer pockets are the hardest part to dry and the writer has been surprised to see how long it takes to properly dry cases, even in the hot sunshine of the tropics. One can help and hasten the drying of primer pockets by wiping them out with a bit of absorbent cloth on the end of a small stick.

The best and surest way of drying cases is with the use of artificial heat, but care must be taken not to overheat them, as too much heat will soften the brass and may render it incapable of withstanding normal pressures. Most modern stoves, whether electric, gas or coal, have oven thermometers that are, at least, fairly accurate. For stoves sold in the United States, these thermometers register degrees Fahrenheit and brass can be heated up to 428 degrees Fahrenheit without undergoing any change in its grain structure. For drying cases it is best to keep the temperature as low as 300 degrees. This heat is amply high for the purpose and offers a liberal allowance for any inaccuracy of the thermometer. If your oven has no thermometer, one can be purchased at small expense in almost any department or five and ten cent store. The thermometer should be placed near the cases as the temperature will not be the same in all parts of the oven. It is also well to place the cases on one of the sliding shelves or racks, away from the bottom of the oven, or the heating element if it is an electric stove.

The sad ending to this little story about cleaning and drying cases is, that after you have spent several shekels for chemicals and thermometers and have spent a considerable amount of time cleaning and drying your cases, you will not have added a single thing to their usefulness for reloading. If, by chance, they have ever been fired with a mercuric primer you will certainly have done them some harm.

The Inspection of Fired Cartridge Cases.

In discussing the relation of cartridges to their chambers, it has been made clear (I hope) that more or less expansion of the case takes place when the cartridge is fired, and that this expansion makes the case fit its chamber more perfectly than it could be made to fit by any other means. It has also been shown that more or less longitudinal stretch may take place, with a consequent weakening of the case. Some of the defects that may occur from these causes have been illustrated and described. The question that will naturally arise in the reloader's mind and especially if he has had little or no experience with reloading ammunition is:— how can I find out what is happening to my cartridge cases when I fire them? The best that can be done here is to give methods for inspecting cases for some of the more important defects. To find the conditions is one thing and to interpret their significance is quite another, the latter requiring long experience and study.

Ignoring overloading to a degree that will cause a firearm to burst, the only danger in reloading ammunition lies in the use of cartridge cases that have been strained or weakened to an extent that might cause them to give way near the head when fired again. The case *must* be in good enough condition to hold the gasses in, and even with reduced loads a failure of the case near the head may cause eye burns of a painful nature or permanent impairment of vision. With this thought in mind, we will confine ourselves principally to those conditions that impair the strength of the cartridge case near the head.

After firing, the cases should be wiped off with a cloth to remove dirt and fouling on the outer surface, after which they can be examined for external defects. Those with splits or cracks should be discarded. In wiping off the cases, do not rub them too vigorously or twist them around with the cloth pressed tightly against them, especially near the head. Brass has the property of charging with dirt and grit, that is, particles of grit become imbedded in the surface of the metal and cannot be entirely removed by any means. Also, if the cases are rubbed too hard, the cloth will pick up some of the surface grit which will act as an abrasive and polish the case nicely, but this polishing may destroy some of the markings that will give an indication of the case's condition. The surface of a fired cartridge can tell many stories to an experienced person.

Incipient or incomplete splits will show as slight wrinkles or depressions of greater or lesser length, running lengthwise of the case. If well forward of the solid head, they may be ignored. True, the case may split completely at this point the next time it is fired, but this will probably do no particular harm.

Incipient ruptures of the body appear as a mottled or wavy band or patch, or as a distinct irregular line on the surface of the brass. Their identification can only be learned from experience and careful observation but as they are of rare occurrence and, in the body of the case, are not dangerous, the reloader can ignore them.

Stretching of the case near the head is usually due to excess head space. This condition will usually, but not always, result in leaving a burnished band around the body of the case near the head. As the side walls are pressed firmly against the walls of the chamber while the powder charge is burning, any appreciable movement of the head to the rear will not only stretch the brass, but the latter, being in intimate contact with the chamber and under pressure, will usually be rubbed or ironed in such a way as to leave this visible band.

To really determine whether the case is weakened near the head and the extent of the weakening, to examine the solid head for possible tears and to find out whether the primer contained mercury or not, it is necessary to section the case. Signs of excessive expansion near the head will suggest the possibility of torn brass but will not prove it. Neither will the examination of a single cartridge case prove that the condition is prevalent in all of the cases that come from one chamber, but if the condition occurs once it will occur again. Where the expansion of the case near the head is sufficient to tear the solid head at all, the cases from that chamber should only be reloaded with reduced loads and then only when the cases are not resized at the head.

To section a cartridge case for ordinary examination, fasten it in a vise by the rim. Any slight compressing of the rim will do no harm for this purpose. With a fine toothed hack saw, carefully saw the case down through the center. The straighter you saw, the less filing there will be to do later. A hack saw will not cut smoothly unless the thickness of the metal being cut is at least equal to the distance between two teeth on the saw, and as cartridge case walls are usually thinner than this, the saw has a tendency to tip or tear its way through the metal. This can be avoided by using a fine saw, then inserting as large a stick of wood as possible into the case, sawing through case and wood at the same time. The wood helps to retard the saw and makes it easier to control the cut. As the thicker portion of the case is reached towards the head, the cutting will become easier and smoother. As a matter of fact, as long as only the lower part of the case is to be examined, the upper part may be sawed off before the case is sectioned. Cutting through the last fraction of an inch of the head may be a little troublesome but it can be done by removing the case from the vise and rubbing it back and forth by hand, with the cut straddling the saw blade. When sawed, one or both halves of the case should be filed by placing the sectioned surface against the face of a bastard file and rubbing it back and forth with the fingers. When the saw marks are filed out, transfer the specimen to a piece of very fine emery or crocus cloth placed on a flat smooth surface and rub it in a direction diagonal to the file marks, until the burrs left by the filing come out. It is unnecessary, for this purpose, to bring the sectioned surface to a high polish but regardless of the degree of polish, there will always be a rubbed skin of brass over the surface that can only be removed by etching. This surface skin must be removed, as it may cover up defects.

To etch the case, immerse it in a 20% solution of nitric acid for a few seconds, or until the polished surface takes on a dull or slightly roughened appearance all over. Do not use too much acid, or the brass will become pitted and pock-marked. When etched, remove the specimen with a pair of tweezers and rinse it in clear water. The action of the nitric acid will clean the fouling from the inside of the case thoroughly and if the surface has a silvery appearance, it is a sure indication that the case has been fired with a mercuric primer. This silver looking coating, which is really mercury, will disappear, into the brass after the specimen has stood a little while, so the condition should be looked for, immediately after taking the case out of the etching solution. Unfortunately, the failure of the mercury to appear does not always offer assurance that the case has never been fired with a mercuric primer, but the mercury will usually show up.

If the expansion at the head has been sufficient to tear the brass in the solid head, the breaks can usually be seen with the naked eye and certainly with an ordinary magnifying glass.

Any stretching of the side walls, due to excess head space, will show up in a reduction of the thickness of the side walls and an annular depressed ring in the brass just in front of the head. If the condition is not severe, that is, if the stretching has only caused a slight reduction in the thickness of the case wall, with no signs of breaking, and if there are no signs of mercury, and if there are no tears in the head, the cases from that chamber and of that particular lot of cases may be reloaded with ordinary full charges, provided they are not resized so as to set the shoulder back at all. This applies to both rimmed and rimless cases. With a rimmed case this means that the reloaded cartridge will be positioned in the chamber by the *shoulder* instead of the rim, as normally, but the head will be in contact with the bolt when it is fired and any further weakening or stretching of the case near the head will be due to spring in the bolt itself or to a forward extrusion of the brass under the thrust of the gasses. One can check on this by reloading and firing two or three cases a few times, sectioning them as described and comparing them with the original sample.

Another point worthy of inspection is the primer pocket. The heads of fired cases should be examined for signs of gas leakage around the primers. Any cases showing black gas smudges radiating from the edge of the primer pockets should be discarded, as the primer pockets have either expanded or have some defect which permits gas to get past the primer cup. The primer cup acts in the same way the case does in the chamber. The side walls of the primer expand to prevent gas from leaking out between it and its pocket, but sometimes the pressure is sufficient to expand the pocket or some defect will permit gas to get by. A little gas will get past the primer, but ordinarily not enough to be noticeable to the shooter. An examination of the face of the bolt of any rifle that has been fired extensively will show the presence of a ring around the striker hole. Whether caused by erosion, corrosion or a combination of the two, this ring has its origin in the gas that, in small quantities, has leaked past primers. If, when de-capping cases, a primer comes out with practically no pressure at all, it is a pretty good indication of an expanded primer pocket and that case should be discarded. If, in seating new primers, a primer goes into a pocket with little pressure, it *may* be due to an enlarged pocket and it may be a small primer. Trying another primer will tell the story. If all the primers go into the primer pockets too easy, it can be due to the primers being too small. This is an unusual occurrence but happens occasionally, especially if the primers are not of the same make as the cases. Expanded primer pockets are an indication that the charges are developing pressures too high for the cases to stand and where this condition is found, the reloader should heed it and reduce his powder charges accordingly.

The Vent. The vents or primer flash holes in cartridge cases are made of a size correct for the primers with which they are loaded at the factory. The size of these flash holes may differ in different makes of cases and, more rarely, in different lots of cases made by the same manufacturer. Where one has a miscellaneous collection of cases, it is well to de-cap them all and examine the vents. Visual inspection alone will enable one to detect any material difference in the sizes of the vents, and to separate the cases into groups

according to the vent sizes. Variations in vents will cause variations in the ignition of the charges, which will affect accuracy and with maximum charges may cause trouble if the vents are too large for the primers being used.

This condition is of increasing importance where the newest non-corrosive primers are being used.

At the same time that the vent sizes are observed, one can inspect the primer pockets for the presence of fouling or primer “ash.” The fouling from our modern non-corrosive primers takes the form of a hard, brittle substance. It is sometimes present in sufficient bulk to prevent primers from being seated flush with or below the surface of the head of the case, and with some primers will afford a sufficient cushion to the blow of the firing pin to affect the ignition. This fouling is easily removed with a bit of cloth over the end of a small stick with a flat end, even running a pointed nail or de-capping pin around the bottom edge of the primer pocket will chip most of it out.

Resizing Cartridge Cases.

The mechanics of resizing cartridge cases is simplicity itself. Some reloading tools have facilities for the full length resizing of cartridge cases and, according to the directions that come with these tools, the cases should be resized full length each time they are reloaded. Now, I have no desire to discredit anyone's statements on this subject. Cartridge cases can be resized completely most of the time, with no other ill effects than a slight loss in the accuracy of the reloaded ammunition, but we have already seen that the complete resizing of an over expanded case may be attended by some danger and in the interests of both the finest accuracy, as well as safety, it is recommended that cartridge cases not be resized any more than is necessary to their proper functioning. In using a reloading tool that is equipped with a full length resizing die, it is not necessary to force the case all the way into the die when operating the tool. Using the tool in this way prevents the shoulders of stretched cases from being set back to their normal position and also avoids any reduction of the case near the head when it is over expanded. At the same time, it does permit the neck to be resized sufficiently to hold the bullet and any slight reduction of the forward part of the body of the case will do no harm under any circumstances.

The hand resizing dies are quite convenient and useful, and cases can be resized completely by driving them in until the heads are flush with, or the rim is in contact with the surface of the die. The cases are driven out by means of a steel punch furnished with the die. In driving cases into the die they should never be struck directly with the hammer or mallet, but should be started in with the fingers and a block of hard wood placed against the head, this latter should then be struck with the hammer to avoid damage to the case.

The vents in primer pockets are made by punching the metal out, and as the punches are small they wear quite rapidly. As their edges get a little dull, the holes are not punched cleanly, more or less of a burr being left around the edge of the hole, on the inside of the case. If a flat faced punch be used to drive cases out of the resizing die, this burred edge will be flattened, reducing the size of the vent. Uniform vents are essential to uniform ignition of the powder charges, so when driving cases out of the die the knock-out punch should always be concave on the end that is inserted in the case so it will not bear on the metal near the vent.

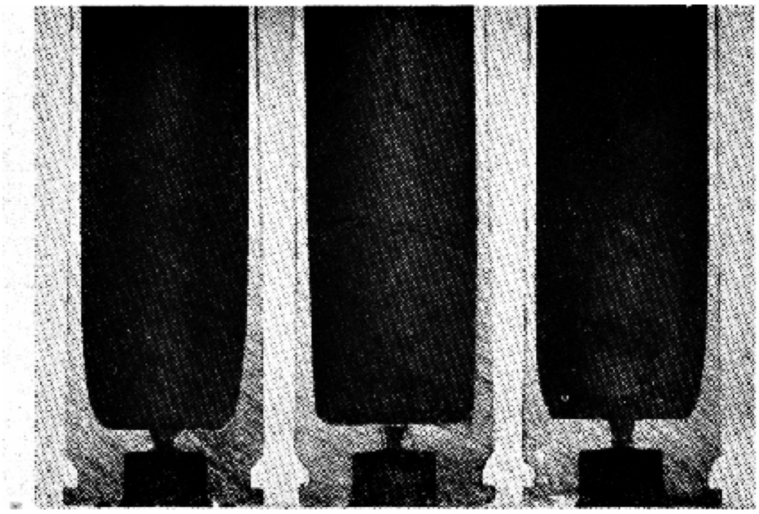
As the complete resizing of cases is not ordinarily desirable, they should only be driven into these hand resizing dies far enough to accomplish the desired result; the desired result, by the way, being to reduce the case only enough to permit it to enter and to be extracted from its chamber without sticking. For partial resizing of cases, the hand dies are not as convenient as those which are mounted in reloading tools, also the exact depth of the resizing cannot be controlled quite as well.

When cases are to be reloaded without resizing them, otherwise than at the necks, they should first be tried in the chamber of the arm they are to be used in. If they can be entered in the chamber and the action closed on them completely, without forcing, they will also enter satisfactorily after they are reloaded. If you have a lot of cases that have been picked up on a rifle range and have been fired in rifles other than your own, you will probably find more or less of them that will not enter your chamber. This is due to the individual differences in the chambers of different rifles of the same caliber. Those cases which do not enter properly will have to be resized to a point that will eliminate the tendency to stick. When a case sticks in a chamber before the locking surfaces of the action are engaged with one another, it is a simple matter to knock it out with a cleaning rod. If the case sticks with the action nearly closed, the situation may be a bit embarrassing for a moment. The usual procedure under these circumstances is to curse and tug or hammer on the bolt or lever of the rifle, in the hope that the extractor will not slip but will pull the case out. Sometimes it does and sometimes the extractor strips off the rim, permitting the case to be poked out with a cleaning rod. The best way to get such a case out, without danger of damage to the rifle or your disposition is as follows:

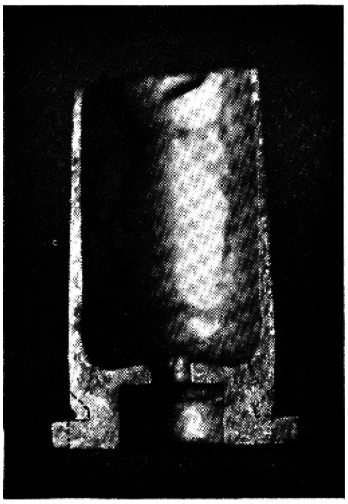
There is always some clearance between the head of the case and the bolt when the extractor is pulling on the rim of the case, so force the bolt up or the lever down until the extractor is pulling properly, then hit the inside of the case a sharp rap with the cleaning rod. This will drive the case back into contact with the face of the bolt or breech block. Repeat the operation a couple of times and that case will come out without trouble.

Before attempting to resize any cartridge cases, they should be wiped off to remove any free grit or dust and then lubricated. A good way to lubricate them quickly is to make a flat pad of a number of thicknesses of cloth and tack it to a board. The pad should then be moistened with a good light oil, such as 3 in 1, after which a number of cases can be placed on it at one time and rolled with the palm of the hand to lubricate them. An excess of oil should be avoided. Vaseline rubbed into the pad is also good.

Cartridge cases fired on a range where the ground is sandy will charge with an excessive amount of grit, which will remain permanently imbedded in the surface of the brass. This grit will cause resizing dies to wear rapidly and will sometimes result in scoring them, after which that die will scratch every case sized in it. The manufacturer can usually polish it out for you without enlarging it enough to render it unserviceable, but a die cannot be polished out more than once or twice at the most.

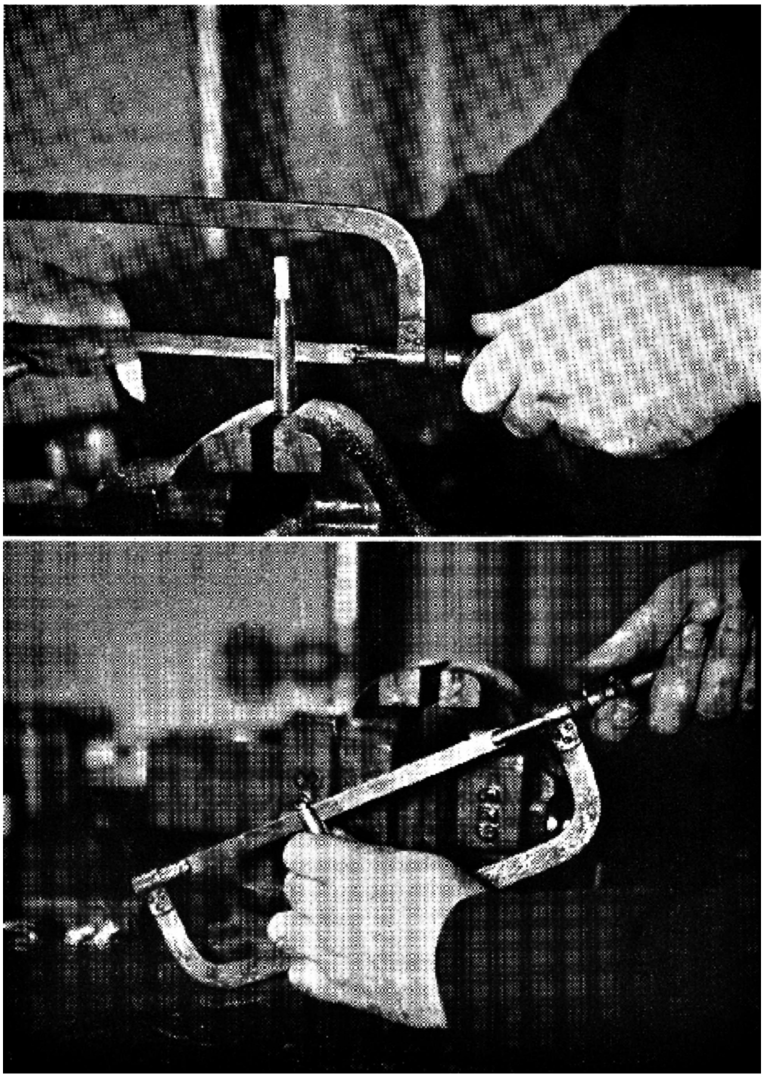


Note difference in head thickness and interior shape of these ·30 '06 cases. The same load will not give the same result in all of them.



Factory cartridge fired once in chamber having loose fit at head— Note torn metal at base which might prove serious with a rimless case.

PLATE III.



Method of sectioning fired cartridge case to prepare it for etching.

PLATE IV.

Now for a word about the dies themselves. Tool steel is, as its name implies, steel for making tools, but it is a general term applied to a *class* of steels and there are almost as many kinds of tool steel as there are kinds of tools. Most of them are not suited to the manufacture of resizing dies.

These that are suitable for dies require careful heat treatment to prevent them from warping. If they are hardened, they become brittle and will break easily. If the hardened die is tempered or drawn to give it a tough structure, it will be softened and will not have a long life under continuous use. The best way to make a die of tool steel suitable for such a use is to "spout" them, When the die is heated to the proper temperature, a stream of water is run through the inside of it, chilling this inside quickly but cooling it more slowly toward the outside. This gives a hard inside surface, with a gradual softer and tougher structure toward the outside that will resist shock. But such dies would be expensive, as their manufacture would be slow and would call for the highest type of skilled labor.

High Speed steel is another misunderstood term. It also is a general term applied to a class of steels developed for making, cutting, turning and boring tools that will withstand the heat of running at higher speeds than are possible with tools made from the ordinary tool steels. High speed steels are tough and hard on the tools used to work them, but none of them are particularly well suited to the making of resizing dies. Pacific can supply their tools equipped with "high speed steel" dies. I have one of these and they do a very nice piece of work on the dies, but if they properly pack harden their carbon steel dies, and I have no doubt but that they do, I would prefer the carbon steel dies.

Carbon steel doesn't mean much either, but the term is applied to the ordinary run of steels of various carbon contents. The low carbon steels machine smoothly and tools used on them have a long life, but low carbon steel cannot be hardened by the ordinary process of heating and quenching in oil or water. Dies made from it can be and are hardened by a process known as "pack hardening," which is similar to case hardening. This gives the inside of the die a very hard surface, a harder, more durable surface than a drawn tool steel die or a high speed steel die, and at the same time a good resizing die can be made in this way at a moderate cost.

Neck Resizing. The expansion which takes place in the necks of cartridge cases when they are fired leaves the necks so large that new bullets will usually drop right through them. If the cartridges were crimped before they were fired, the crimp will not "shoot out" entirely and the mouths of the cases will have enough crimp remaining to offer an obstruction to the entrance of new bullets. This

remaining crimp must be removed, so it is often desirable and sometimes necessary to resize the cases at the necks, before attempting to seat new bullets.

Neck resizing is *necessary;* when the reloading tool operates with the case in a vertical position, in order to keep the bullets from dropping inside during the seating operation; when jacketed bullets having no crimping grooves or cannelures are used; and when cast bullets either have no crimping grooves or are seated to a depth that leaves the mouth of the case at a point on the bullet inconvenient for crimping. If the bullets have crimping grooves conveniently located, excellent ammunition can be reloaded without resizing case necks at all, provided the design of the loading tool will permit this method of loading. Ammunition so loaded will be found to have the bullets more or less loose, and they can always be turned around with the fingers. This does no harm from an accuracy standpoint and is often an advantage but, as a rule, it is desirable to resize the case necks in order that there will be no chance of the bullets coming out in the ordinary handling and loading of the ammunition.

If the cases are resized full length, the necks will be reduced at the same time, and some loading tools will also expand the necks to the proper diameter to receive and hold new bullets at the one operation.

Resizing case necks is divided into two operations; the reduction which should be sufficient to make the inside diameters of the necks a little too small, and the expansion which opens them up to the correct diameter. This procedure is followed in the manufacture of new cases also, the expanding operation being known as "ball sizing." It is necessary because, due to differences in the thickness of the brass in the walls of case necks, it is impracticable to bring the *insides* of the necks to the correct diameter by simply resizing the *outsides.* Even cases of the same make and lot will vary in thickness at the necks, also the thickness will not be uniform all the way around the necks, except by chance. The temper of the brass also has a material effect upon the way the necks resize. All other things being equal, hard brass will spring back more than soft brass after the necks are either reduced or expanded.

In order to produce neck reducing dies, or "muzzle re-sizers" as they are generally called, economically, manufacturers of loading tools must make one standard size for each caliber of cartridge. These are made of a size that will reduce the thinnest cases sufficiently and as a consequence they will reduce cases with thicker necks a little too much; or more properly, a little more than is necessary. This does no serious harm but it will shorten the useful life of the cases, especially if the brass happens to be harder than normal.

Expanding plugs of different diameters may be obtained to meet the requirements of the bullet being loaded. The general rule is to use an expanding plug that is the same diameter as the bullet. As the brass springs back slightly after the neck has been forced over the expanding plug, its inside diameter will actually be one or two thousandths of an inch smaller than the plug or the bullet, and the latter, when forced into the neck, will be held firmly by the tension of the brass.

Another way to expand necks and one that, if followed, will overcome most of the difficulties that may be encountered with this operation, is to use an expanding plug that is a thousandth of an inch or two *larger* than the bullet. This plug should only be forced into the neck about one third the length of the seating depth of the bullet. This will expand the mouth of the case so that the bullet can be set into it perfectly straight and for a sufficient distance so that there is no possible chance of its tipping. The seating is completed in the tool, the bullet acting as its own expander for the remaining distance. Even cast bullets with plain bases may be seated in this manner, and there will be no chance of their being scraped or shaved during the operation. Some cases, the ·22 Hornet being a notable example, have very thin necks and sometimes bullets cannot be seated friction tight except by the method just described. As it takes much less force to expand the thin walls of a case neck than it does to compress a lead bullet, this method of expansion will be found satisfactory with any kind of bullet.

Bullet Pull. When commercial or military ammunition is loaded, it is subjected to a test to determine the amount of force or pull required to draw the bullets out of the cases. This is done to insure that the bullets will not come out from handling, or loading and extracting the cartridge from an arm. There is a minimum pull allowed, below which the ammunition would not be satisfactory, but as long as the bullets cannot be pulled out too easily, it generally doesn't matter how tight they are. It is commonly believed that a variation in the tension under which bullets are held in place makes a great deal of difference in the way the ammunition shoots, also that a cartridge in which the bullet is held very tightly will develop a much higher pressure than a similar cartridge with a looser bullet. Perhaps there is some slight difference, but from a practical standpoint it doesn't amount to a hill of beans. Bear in mind that we are speaking now of the tension of the neck on the bullet and not of crimping, which will be discussed later.

No one knows positively what takes place inside of a cartridge when it is fired, but by observation of some of the known factors it is possible to make deductions that are logical and probably correct. When a powder charge starts to burn, gasses are formed which, being confined, build up pressure inside the case. The pressure starts from zero and increases as more and more of the powder catches fire. Due to the weight and inertia of the bullet, it does not start forward into the bore at once. As the walls of the cartridge case are thinner and weaker at the front than at the rear, and as it requires less time and pressure to expand the thin neck of the case than it does to start the bullet forward, the case lets go of the bullet, allowing more or less of the gas to escape past it. As the pressure increases, the inertia of the bullet is overcome and it moves forward into the bore, practically sealing the bore and preventing further escape of gas. If the case lets go of the bullet before the latter starts forward, leaving it free and floating around by itself as it were, how in the name of common sense is a few pounds difference in the force required to pull a bullet out of a case going to have any retarding effect upon the forward movement of the bullet when the cartridge is fired?

Tight Chambers.

Some custom made barrels are purposely turned out with exceptionally tight chambers, in order to improve their accuracy. It is necessary to distinguish between minimum chambers and tight chambers. The former is the smallest chamber that is considered permissible in commercial or military arms, while the latter are smaller even than a minimum chamber; so small and tight in fact that commercial ammunition will not always enter them. In making cartridge cases for use in tight chambers, commercial cases are used but they are re-reformed so as to fit the chambers perfectly, the necks being turned on the outside to eliminate the inequalities in thickness of metal and to make the out-side concentric with the inside. Their outside neck diameter is usually an exact fit for the neck of the chamber.

When such a case is loaded and fired there is no expansion of the neck and consequently, little or no gas escapes past the bullet during the interval between the time the powder starts to burn and the bullet starts forward to seal the bore. There is also very little expansion of the body of the case. As *all* of the gasses are confined within a rigid cavity (by rigid is meant that there is no cushioning effect from the initial expansion of the case) and as the chamber is of smaller volume than normal, the pressures developed in a right chamber will be higher than if the same cartridge and load were fired in a commercial chamber. But tight chambers are impractical. Cartridge cases often require more than ordinary force to extract them, at least to a degree that is not permissible in hunting and military arms; and besides, it is impractical to maintain such a close relation between cartridge and chamber in commercial production. Nevertheless, a condition approaching that of the tight chamber is sometimes found in a few commercial arms and ammunition, notably in the ·220 Swift and the ·257 Roberts, in these calibers, the difference in size between a maximum cartridge and a minimum chamber is hardly more than ·001 inch. It is of course, slightly more between a maximum chamber and a minimum cartridge, but the tolerances are remarkably close.

The normal performance of ammunition in these calibers contemplates enough expansion at the neck of the case to let go of the bullet. If, for any reason, the necks of the cases cannot expand, the chamber pressures will increase to an abnormal point and may be dangerous. It has been pointed out that sometimes there is a forward movement or extrusion of the brass in a cartridge case, probably due to the thrust of the expanding gasses. In an ordinary chamber, the thickening of the case neck which results from this is insufficient to prevent the neck from expanding and letting go of the bullet when the case is reloaded, but in chambers having tight necks the situation is different. A little added thickness at the neck may be enough to cause excessive pressures.

For this and other reasons the writer believes that the reloading of cartridges of the calibers mentioned, or of any caliber where the neck of the case is a very close fit in the neck of the chamber, should not be attempted by the novice at reloading if full charges of powder are used. In fact, the beginner had best keep to reduced charges with any caliber of ammunition until he has acquired experience, and has learned something more than the mere mechanics of assembling ammunition.

The resizing of cartridge case necks for chambers with close tolerances differs from the usual perfunctory reducing and expanding of the case necks. Where a chamber is known or believed to be unusually tight at the neck, this part should be carefully measured. Directions for making sulphur casts for this purpose are given elsewhere in this book. After determining the size of the chamber neck, proceed as follows: Reduce, or reduce and expand, the necks of the cases until their *outside* diameters are at *least* two thousandths of an inch (·002″) smaller than the neck diameter of the chamber. If a greater reduction than this is necessary to leave the insides of the necks small enough to hold the bullets, so much the better. When your cartridges are loaded, measure the necks of *all* of them and set aside any that are not *at least* ·0015″ smaller at the neck than the chamber neck. The bullets should then be pulled from these cartridges and the insides of the case necks reamed out until they can be sized to hold the bullets without enlarging the outside neck diameter too much. Don't make the mistake of measuring but a few of your cartridges and assuming that the rest are like the ones measured. These thick necks only occur once in a while, and while you may never encounter one, they are of sufficient importance to watch out for. Their occurrence is not limited to any particular calibers and the condition is *only* of importance in chambers having tight necks.

CHAPTER TWO

PRIMERS.

The handloader should understand that the primary function of a primer is to ignite the powder charge promptly, adequately and *uniformly.* What the primer may be made of, or any other special properties it may have in addition to its ability to ignite the charge, are incidental and of secondary importance. Emphasis may be placed upon ignition properties of a primer to the same degree that it is placed upon the function of the cartridge case as a gas seal. Both are fundamental.

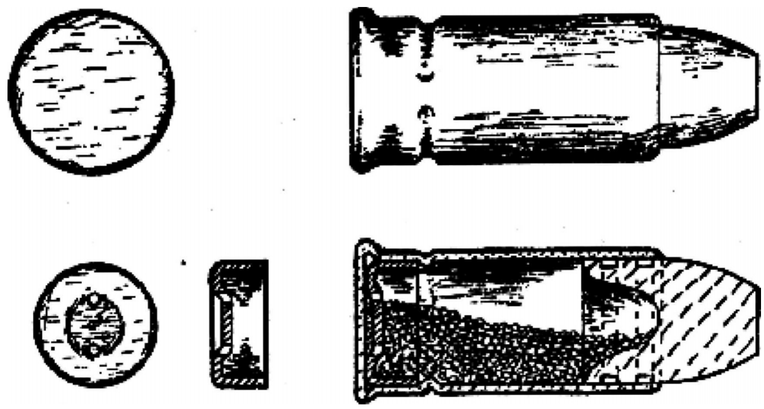
The type of primer that we are most familiar with today and the one to which we will devote the most attention, is composed of three principal parts; a metal cup, a pellet of explosive priming compound which is pressed into the cup, and a metal anvil against which the priming compound is driven by the firing pin to explode it. This type of primer is a product of evolution and to understand the reasons for this type of design, its virtues and its limitations, it is necessary to know something of the general types which preceded it.

Our Civil War was fought for the most part with muzzle loading arms which were fired with percussion caps. These caps were made in a number of forms, but the most common and the best took the form of a thin copper cup having the priming compound pressed into it and usually covered with a thin disc of tin foil. This fitted tightly over a steel nipple on the barrel, with the priming pellet in contact or close to the top of the nipple. The nipple was provided with a hole leading to the powder chamber and its upper edge was flat. When the hollowed face of the hammer struck the cap, the pellet was pinched between the bottom of the hammer cup and the flat surface of the nipple, causing it to explode. The flash produced passed on to the charge, igniting it. It will be seen that this system had all the elements of our present day primers; a cup, a priming pellet and an anvil against which the pellet was exploded.

The demand for arms during the Civil War period and especially for arms that could be reloaded more rapidly than the muzzle loaders, led to the development of the breech loader, the metallic cartridge and the repeating rifle, many novel breech loading systems making their appearance in rapid succession. The first practical repeating rifle was the Spencer, which used a rim fire cartridge of large caliber.

Rim fire cartridge cases are made from thin metal and in folding or forming the rim, a space is left into which the priming mixture is “spun,” forming a ring of priming around the rim of the case. The firing pin must strike the cartridge at the rim in order to pinch the priming and fire it. This type of priming is unsatisfactory in large caliber cases. The ring of priming is brittle and structurally weak and in the ordinary handling and loading of the cartridges, pieces of priming break away, leaving dead spaces which, if struck by the firing pin, will result in mis-fires.

A lot of muzzle loading arms were converted to take the then new metallic cartridges and the design of some arms made it easier to convert them to fire a center fire cartridge. One type of center fire cartridge that enjoyed a short period of popularity was made with an internal primer. The case itself looked like a rim fire case and the primer was in the form of a pellet, crimped into the base of the case, on the inside. But this type of case was *not reloadable.* The reloadability of ammunition and the people who have reloaded it have had a great influence upon the development of our ammunition, not only in the past but at the present time as well. Many a reloader with a little time and money at his disposal, plus the ability to experiment intelligently, has contributed to the development of factory loaded ammunition. Cartridges were expensive in the early days of the ammunition industry and money was scarcer than it is today, consequently the reloadability of ammunition was important to the owner of any firearm. Even today there are thousands of shooters who, because of the expense of factory ammunition, would never purchase firearms were it not that they can easily reload their fired cartridge cases with a few simple tools and thus provide themselves with an abundance of ammunition at small expense.

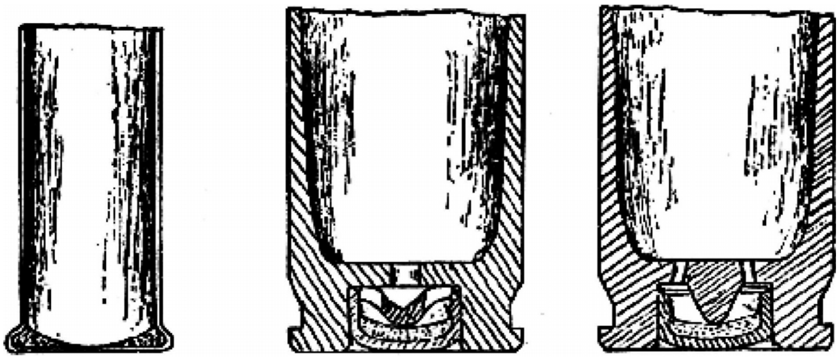


An early center fire cartridge—made with an internal primer.

The immediate forerunner of our present primers was what is commonly termed the "Berdan" primer, named after its inventor, a Colonel Berdan of the Union Army. This primer takes the form of a cup similar to that used in our present primers. This cup contained the primer pellet but had no anvil. The anvil was formed in the bottom of the primer pocket and was part of the cartridge case. Flash holes or vents were drilled at the base of the anvil and were usually two or three in number. The Berdan primer has certain points in its favor, perhaps the principal of which is that the anvil in the primer pocket, being of solid brass, is more rigid and offers greater resistance to the blow of the firing pin than the separate bent metal anvil which we now use. But from a reloading standpoint the advantage is all the other way. Berdan primers are used almost exclusively in European ammunition, but it should be borne in mind that firearms were never used as extensively by the general population of European countries as here in the United States and consequently reloading has never attained the wide spread popularity that it has here. Europe was, as it is now, a collection of settled countries with fixed frontiers (as long as the politicians left them alone) while in the United States the condition was different.

At the lime when firearms and ammunition were undergoing their most rapid development we were a new nation; one that had been hacked out of a wilderness and one in the development of which firearms had played a most important part. Furthermore, at that particular period, we had a rapidly expanding frontier towards the West, where firearms in the hands of the settlers were indispensable tools. Our ammunition problem was different from that of Europe and the problem of reloading fired cartridge cases was an important part of it.

The Berdan primer did not meet the requirements of the reloader satisfactorily. The anvil in the center of the primer pocket, with small vents around it, did not permit easy expulsion of the fired primers. They could not be forced out from the inside but had to be dug or pried out from the outside, which was inconvenient. The vents were small and were easily clogged by fouling or corrosion, the latter sometimes forming after the ammunition was reloaded. The early folded head cases had anvils that were merely pressed into shape, these were not of solid brass and a long firing pin would deform them and reduce their height. However, black powder is easily ignited and minor damage to Berdan anvils did not have any appreciable effect upon ignition. The objection to the Berdan primer from a reloading standpoint was chiefly a mechanical one, but with modern smokeless powders any damage to the anvils, whether from corrosion, erosion, or mechanical causes, will affect the order of explosion of the primers. Any lack of uniformity of the anvils will result in variations in ignition and, consequently, in muzzle velocity. Early attempts were made to overcome the difficulty of de-capping cases by providing a central hole through the anvil, sometimes by itself and sometimes with vents at the base of the anvil as usual. The single flash hole through the anvil was unsatisfactory. In the first place, this design removes the support from the place it is needed most, that is, right under the point of the firing pin. In the second place, the flash produced by the primer was limited to that produced in the immediate vicinity of the flash hole, the indentation of the cup practically closing the vent. With other vents at the base of the anvil the ignition was improved, but the central vent still failed to give sufficient support to the pellet and the anvils were subject to the same rigors of repeated firing and reloading. This idea of putting a central vent in a Berdan primer anvil has been "rediscovered" a number of times during the past sixty years, but it is fundamentally wrong and thus far has always ended up a failure. It does permit primers to be forced out from the inside of the case with the conventional de-capper having a pin on the end for the purpose, but that is about the extent of its rather questionable advantage.



RIM FIRE SEPARATE ANVIL PRIMER "BERDAN" PRIMER

Now let's take a look at the American type of primer in comparison, with its separate anvil assembled with the primer and one central flash hole in the primer pocket. Let us grant that this anvil is less firm and more likely to collapse under the blow of a firing pin than the solid Berdan type. The superb accuracy we obtain with our match ammunition would seem to indicate that there was nothing wrong with the ignition and that the objection referred to was purely theoretical but the answer is, that our anvils are too *near* the line of being unsatisfactory. They do collapse to a certain extent, cushioning the blow of the firing pin; also, unless they are properly made and hardened by cold work, they can cause ignition difficulties. Very well. We will give the Berdan anvil the edge in *new* ammunition but *not* in reloaded ammunition. Our primers are easily expelled; the primer pockets offer no irregularities but are easily cleaned of fouling to give new primers a firm seat on the bottoms of the primer pockets, and as each primer has a new anvil incorporated in it, it is possible to get uniform ignition regardless of the number of times that a case is reloaded. So much for general types of primers.

The reloader can do no more than purchase primers and use them. He can't make them and he can't change the ones he buys, so at first glance, it may seem useless to say much about the way they were made. Nevertheless, the primer is the very heart of a cartridge and the use of an improper primer or one that is improperly seated can defeat all the pains and care that you may take in reloading ammunition. And what is an improper primer? Simply one that does not ignite powder charges uniformly and adequately. A primer that may be unsatisfactory with one load may be excellent with another charge of a finer or more easily ignited powder. Judging from an extensive correspondence with reloaders in this and other countries, the popular belief is that accurate ammunition depends upon extreme accuracy of powder charges and uniform bullet diameters and weights. Up to a certain point, yes, but primers can make a lot more difference in accuracy than any little differences in the weights of powder charges, and reloaded ammunition that shoots fairly well can often be made to shoot better, simply by changing primers. It therefore seems permissible to look closely at the way primers are made and why.

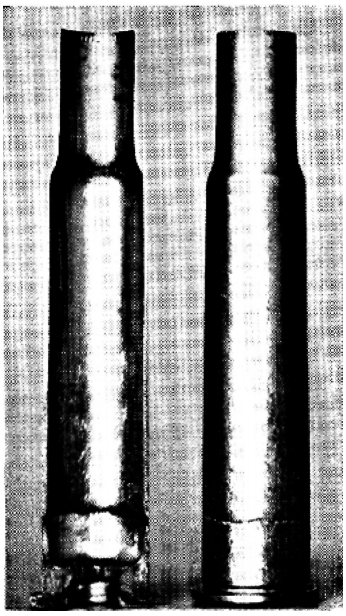
The Primer Cup. The function of the primer cup, in addition to holding the priming pellet, is to prevent gas from escaping to the rear. It functions in the primer pocket that same way that the case does in the chamber. Under pressure, the walls of the cup expand against the wall of its pocket; thus forming a gas seal. Primer pockets are not always perfectly round and even though primers seem to fit them tightly there is usually enough space somewhere around them to permit air or water to enter, therefore commercial and military primers are waterproofed after loading, by allowing a little varnish or lacquer to flow around the edges of the primers to fill these minute crevices.

The cups must be soft and thin enough to be properly indented by the firing pins of the arms they are to be used in, at the same time they must be strong enough to hold in the pressures developed within them. The sensitivity of the priming mixture influences the design of the primer cup also. Some mixtures require a harder blow to explode them than others, with such, a thick or stiff primer cup might absorb too much of the blow of the striker to cause a proper and uniform explosion. If a mixture could not be fired with a cup strong enough to support the pressure developed, that mixture would have to be discarded. Therefore, the differences in hardness that is found between primers of different makes is not a matter of chance but is the result of careful study and experimentation on the part of the manufacturers. A primer having a stiff or thick cup is not necessarily better than one having a thinner and softer cup, except that the former can be seated with less liability of deforming it in the process.

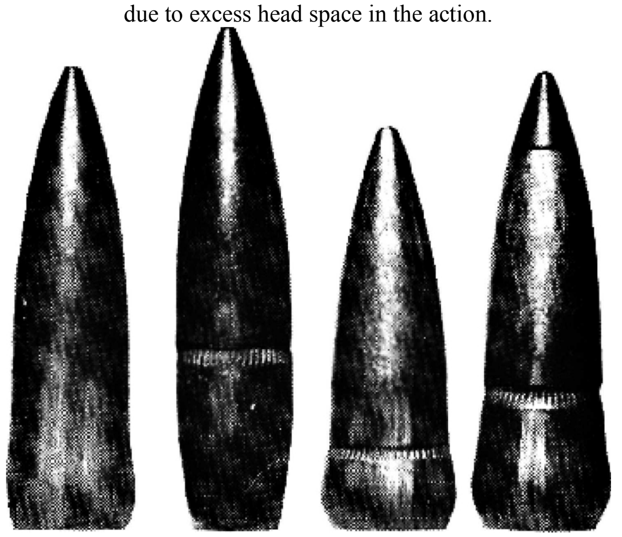
Generally speaking, primers for rifle cartridges are made with thicker and stiffer cups and contain more or hotter mixtures than primers intended for use in pistol and revolver cartridges. The rifle primers are made stiffer or thicker because the firing pins of rifles usually strike harder blows than those of pistols or revolvers. Furthermore, the pressures built up inside of rifle primers are much higher than those developed in pistol primers so, if too thin or too soft metal is used in the cups, the primer will be pierced, permitting gas to escape through the action and possibly causing eye burns.

Pierced primers may be caused by too long or too sharp a firing pin, but the more common reason for them is failure of the primer cup at the point where it is struck. The cup is weakened where it is indented and if the pressure within the primer be too high, the weakened portion may blow back through the firing pin hole and permit gas to escape at the same time. When this happens, the striker or firing pin is blown back violently and may be damaged. Firing pin holes that have worn large or become eroded by escaping gas may not support the center of the primer sufficiently and may permit a circular piece of the cup to blow out. This condition can often be detected by examining fired primers and observing the area of that part of the primer which has set back into the firing pin hole, in relation to the indentation of the firing pin. There must, of course, be a little play around the firing pin in order to permit it to act freely and without sticking in its forward position, but the difference in the size of the hole and the firing pin should not be excessive. It is well also to examine the firing pin itself, as the trouble may be due to its wear rather than to the hole through which it passes.

The amount of pressure developed inside of the primer is influenced by the size of the vent. If the pressure within the case were maintained long enough, the primer pressure would be equal to the chamber pressure but the cycle of ignition and combustion is so short that there is not time for the pressure to equalize itself in these two cavities. In spite of this, the primer pressure will increase as the size of the vent increases.

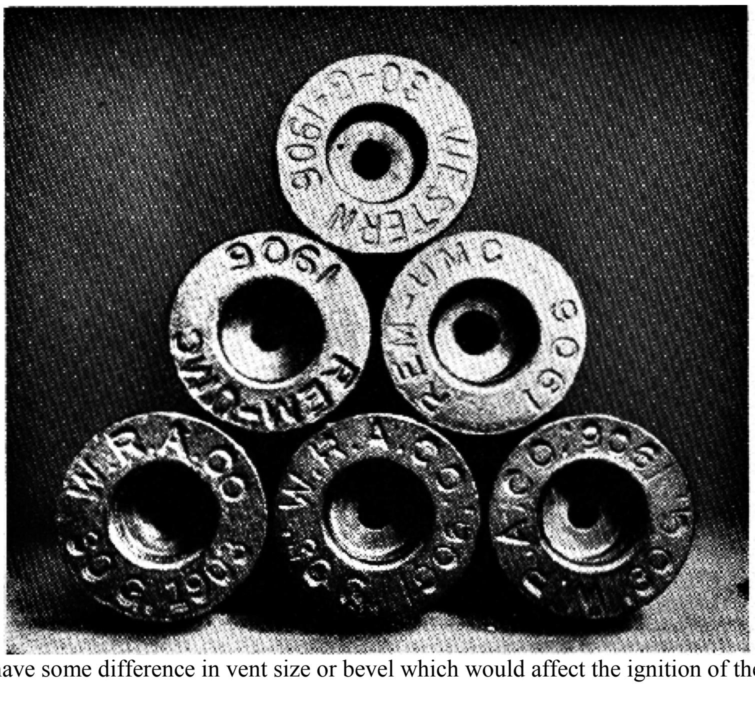


Halved sections of a ·30/40 case which has been fired with a mercuric primer, then polished and etched. This case had split and stretched at the head, due to excess head space in the action.

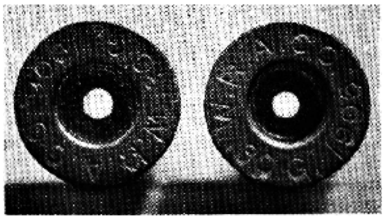


Showing upsettage of bases of flat *base* bullets in comparison with a boat-tail bullet which does not upset when fired. Upsettage depends upon the structure of the bullet, its hardness, the force applied behind it and the suddenness with which the force is applied.

PLATE V.



All of these cases have some difference in vent size or bevel which would affect the ignition of the charge differently.



The vent size may be different in various lots of the same make and caliber of cartridge case.

Cracks sometimes occur in the bottom of primer pockets. This defect is traceable to the use of mercuric primers and is, I believe, limited to folded head cases such as are used in much of our present day revolver ammunition. As primers should never be seated without inspecting the primer pockets first, this defect will be easily observed. Its effect is to permit an excessive amount of gas to reach the primer, driving it back violently against the recoil plate of the revolver, setting back or cracking this part and necessitating sending the arm to the factory for repairs. The webs can be broken to an extent that will permit the primer to drive forward without firing at all, then again there may be enough resistance to cause the primer to fire. The broken web can permit a greater amount of flash than normal to reach the charge and cause over ignition of the powder, with attendant high pressure.

Some reloading tools have apparently been designed with more thought about speed of operation than the elementary principles of reloading, and the operations of de-capping and re-priming have been combined with no consideration whatever of permitting proper inspection of the primer pockets before seating new primers. Fortunately, all of these tools permit the two operations to be divorced from one another and the reader should be wary of the tool that doesn't.

Primer Pellet. The primer pellet is the fire producing or business part of the primer and it is made from a mixture of several ingredients, as there is no one substance suitable for the purpose. Small arms primers are fired from the blow delivered by a firing pin and the force available is limited, making it necessary to use at least one substance in the mixture that is very sensitive to shock. This element which starts the burning of the primer is usually called the “initiator” and it must be a substance that will explode on receiving a sudden shock or blow from a firing pin. Its positive action depends upon a second, or frictional element, which is a rough, hard substance incorporated in the priming mixture. The third element is the “fuel” or that part of the mixture which produces the flame. This flame must be of sufficient length and duration and must produce enough heat to ignite the powder charge properly. The priming compound, in its action, can be likened to a blue-tip match. The tip of the match is the initiator; the rough side of the box the fractional element, and the head of the match is the fuel which must burn long enough to ignite the wooden match stick. A different arrangement, but the same general idea. Some initiators produce a considerable amount of heat, but because of their quick, violent nature the heat does not last long enough to accomplish its purpose. Likewise, some frictional elements are good fuels, while others, notably ground glass do not burn at all but apparently become incandescent when the primer explodes and thus contribute in a way to the ignition of the charge.

It used to be believed that ground glass from primers caused a scoring of the throats of rifle barrels. The writer doubts this, for *if* the glass becomes incandescent, and there is evidence to indicate that it does, the hot particles would be too soft to score the barrel. Besides, ground glass is still used in some of our present day primers and long series of shots fired with such primers show no injury to barrels. It would therefore seem that the old prejudice against ground glass as a frictional element in primers was unjustified and that the scoring referred to was in reality due to erosion. Erosion has only become of interest to ballisticians in comparatively recent years and while what is known of it is largely from the standpoint of results rather than causes, it is certain that the condition, is in no way dependent upon ground glass in primers.

Chlorate Primers. The first initiator used in small arms primers successfully was fulminate of mercury. As it is too quick and violent in its action to make a good primer by itself, it was combined with potassium chlorate, the latter being an initiator as well as a fuel. Both of these substances have formed the basis of primers for small arms up until only a few years ago and our military primers are still made without fulminate of mercury, but with potassium chlorate as the principal ingredient. No primers are made with these two substances alone, others must be incorporated with them to produce good priming mixtures. Both chlorate and chlorate-fulminate primers are excellent from an ignition standpoint, but like all good things, there is some evil in them. Potassium chlorate primers, when fired, leave a deposit in the barrel that gathers dampness rapidly, causing rusting, therefore arms fired with these primers should be cleaned promptly after firing, preferably with water, as oil or nitro solvents that do not contain water will not dissolve this fouling.

Any primer containing fulminate of mercury is termed a mercuric primer; when fired, the mercury will attack the brass cartridge case and often render it unfit for reloading— and the reloaders never did like that.

Non-Corrosive Primers. For many years ammunition manufacturers have been experimenting with other initiators, in an effort to get away from the corrosive evils of potassium chlorate, so a few years ago the first of the so-called non-corrosive primers made their appearance. The term “non-corrosive” as applied to these primers is a misnomer as many of them will, by themselves, leave a deposit on steel that will cause rusting to a greater or less extent. When properly made, and loaded so that the products of combustion from the primer are combined in proper proportion with the other products of combustion, the *ammunition* is non-corrosive and the fouling from it will not rust the barrel. The production of non-corrosive ammunition requires a study of *each* caliber and loading of cartridge, as the quantity and composition of the primer mixture must be governed to produce both good ignition and non-corrosive properties.

The great majority of non-corrosive primers being loaded in factory ammunition at this time contain fulminate of mercury and the one manufacturer who has been loading non-mercuric primers is swinging back to the use of fulminate of mercury. Why? Because fulminate of mercury produces heat and its use in these primers makes them better igniters, without destroying the non-corrosive properties.

The non-corrosive primers sold for reloading purposes do not contain fulminate of mercury and while they are of the so-called non-corrosive variety, they cannot be depended upon to be entirely non-corrosive in their action because of the inability of the handloader to control the products of combustion of the powder charge to produce this effect. They will be less corrosive than the old chlorate primers but the wise shooter will do well to clean his guns after shooting them when using reloaded ammunition. Of course the *wise* shooter cleans his guns after shooting any kind of ammunition, so that admonition is probably superfluous.

Another thing to watch out for is the mixing of non-corrosive primers, that is, firing more than one brand of primer without first cleaning the bore thoroughly. Each manufacturer has his own primer formulas and they do not all use the same ingredients in their primers. The products of combustion of two different makes of primers, if mixed, can and may cause rapid rusting of the barrel.

Mercuric Primers. A mercuric primer is *any* primer that contains fulminate of mercury, regardless of what other properties it has. When a cartridge case that has been fired with a mercuric primer is reloaded and fired again, the brass will crack to a greater or less extent. These cracks may be very minute internal cracks, but once they open up they permit the mercury to penetrate deeper into the brass and it is only a question of time before the case will crack completely through. The illustration on Plate X shows an automatic pistol case that has been fired to destruction. This case was originally loaded with a mercuric primer, then was reloaded and fired three times with primers that did not contain fulminate of mercury. The result shown in the picture was brought about by the mercury in the primer with which the cartridge was originally loaded. It will be readily understood that had this condition occurred with a rifle cartridge loaded with maximum loads, the result would have been serious for the gun.

Because of the low pressures developed in pistol and revolver cartridges, mercuric primers are not a source of danger in the ammunition used in them when loaded with reduced or even normal loads. The damage that they do is usually limited to the ruination of the cases after they have been reloaded a few times. This is not true of ammunition reloaded with maximum or excessive charges, although when a handgun lets go the damage is principally confined to the gun and the hand holding it.

Primer Anvil. Primer anvils are made of hard worked brass, that is, they are made as hard and stiff as possible without being brittle. Their form has much to do with the performance of primers and they are made so they will serve their purpose even though the firing pin does not strike precisely in the center of the primer. As both factory ammunition, and reloaded ammunition the cases of which have been resized, are a trifle loose in the chambers of arms, the cartridges naturally lie in the bottoms of the chambers. The firing pin holes are opposite the centers of chambers and this frequently causes the firing pin to strike above the center of the primer. Looseness in the firing pin itself may also cause it to strike off center. This can be considered as a normal condition under the circumstances mentioned and primers must function with reasonable satisfaction under such condition. Theoretically, it is an undesirable condition and can be at least partially avoided by using cartridge cases that have not been resized near the heads. Just how much practical difference in ignition may be caused by the off-center blow of the firing pin this writer does not know but it must cause some slight difference, at least if the condition is aggravated. Otherwise the anvil form would be a matter of small consequence.

When anvils are forced into the primer cups, they are left flush with or projecting slightly beyond the edge of the cups. They are never below the edges of the cups. This is done to permit the anvil to rest firmly upon the bottom of the primer pocket, so it will form a solid support to the blow of the striker. If, for any reason, the anvil is not so supported, the blow will be cushioned and the primer will not deliver its full efficiency.

Seating Primers.

This is one of the most important operations in loading ammunition for, granting that the primer is suitable for the cartridge and load, failure to seat it properly will defeat all the care that has been used in the manufacture of the primer and the loading of the ammunition. The present non-corrosive primers sold for reloading purposes are pretty good igniters, but they have some characteristics that make it imperative to seat them carefully in order to get uniform ignition.

The older chlorate and chlorate-fulminate primers were made with wet priming mixtures. The ingredients were mixed with a gum arabic solution to increase the safety of loading and the pellets, when dried out, had slightly elastic properties, due to the gum binder. These primers could and can be seated with quite a heavy pressure without breaking the pellets, and ammunition loaded with them will shoot quite well, even if the primers are seated with sufficient pressure to mash the cups flat. Not that I recommend this however. Excessive pressure will increase their sensitivity as a rule, and while some variation in ignition must occur when the pressure of seating them is not uniform, they are nowhere near as temperamental as the newer primers.

Most of the non-corrosive primers are loaded with a dry mixture and the pellets are formed only by the pressure applied to them. These pellets are brittle and are easily broken if too much pressure is applied to the primers in seating them. More than one lot of factory ammunition has been broken down and loaded over again, because the priming machines exerted a little too much pressure in seating primers that had been previously tested and found satisfactory. Naturally, it only takes one experience of this kind to put a manufacturer on his guard against a recurrence, but the reloader, using hand tools and miscellaneous cases that do not all offer the same resistance to the primers when they are seated, must be especially careful with this operation.

Some reloading tools seat primers by means of a powerful lever, the leverage being excessive for the purpose. Such tools must be used with great care when seating primers. They are alright, but in operating them the operator should use more brains than brawn. The Schmitt reloading tool has an adjustable stop to limit the travel of the priming punch and, if this stop is properly adjusted for the primers and cases being loaded, it is an effective check against applying too much pressure to the primer. If it is not properly adjusted, all of the primers will be improperly seated. In this connection, it should be born in mind that the primer pockets of different makes and lots of cases are not always of the same depth, even though they are of the same diameter.

Sometimes a reloader finds that when he has his primers seated firmly on the bottoms of the primer pockets, they still project above the heads of the cases. This is almost invariably due to the use of primers that are of a different make than the cases and it is a dangerous condition, as a cartridge with a protruding primer may fire if dropped or by the closing action of the bolt or breech block, if the action is closed violently as in rapid fire or in automatic arms. The illustration on Plate X shows a primer that fired accidently from this cause. Note that the mark of the firing pin *hole* is visible but that there is no mark of the firing pin itself. This is but one reason why it is advisable to use primers of the same make as the cases being reloaded.

Primer Pocket Vents. Another reason for using primers and cases of the same make lies in the sizes of the vents. These vents are of a size suitable for properly igniting the charge with the primer *with which they were loaded at the factory.* While the primers made by the same manufacturer and sold for reloading purposes may not be the same as those with which the ammunition was originally loaded, they will be nearer to it than those of another make.

As an extreme example of the importance of vent size to ignition, the heads of two ·38 cases are shown on Plate X. One is a Remington case using a *small* primer and having a relatively *small* vent. The other is a Peters case using a *large* primer and having an abnormally *large* vent. We can safely assume that both of these cartridges were equally satisfactory as originally loaded, but it is obvious that the Peters priming mixture used in this instance was less efficient than the Remington mixture and required a larger amount of mixture and a larger vent to obtain proper ignition of the powder charge. The kind of powder used may have had some influence on this however. Now, a large Remington pistol primer will fit that Peters case very nicely, but if we use the Remington primer in it, we will certainly get over ignition of the charge. The vent is too large and the greater quantity of more efficient priming mixture is too much for this cartridge. A maximum load fired with such a combination would certainly be dangerous but then, maximum loads should never be loaded into cases with abnormally large vents, if at all. The large vent will permit a terrific set back of the primer.

If we reverse the order and put a small Peters primer in the Remington case having a small vent, it is obvious that the ignition will be insufficient. The quantity of priming will be too small and the vent isn't large enough, even if the case would take a large size Peters primer. This comparison assumes the use of priming mixtures such as were used in the original loadings. It does not intend to show that one make of primer is better than another, but rather that *any* primer must be used with the proper size of vent to be efficient.

With the older corrosive primers, each manufacturer had his own formulas but these differed only in minor respects and therefore, it was generally permissible to use primers of different makes than the cases they were loaded into, provided they were of the proper type and size. This is not so true of the modern non-corrosive primers. These primers should only be used interchangeably in different makes of cases where the primer pocket sizes and the vents are of the same size.

For the best accuracy and most uniform ignition, the fouling should be removed from primer pockets before new primers are loaded, so that the anvils will rest on solid brass rather than on brittle fouling. You will get pretty good results most of the time if the primer pockets are not cleaned, but the reloader who really wants to produce good ammunition will clean them out. This primer fouling is bulky and can prevent primers from being seated flush with or below the surface of the case heads. Every precaution you can take to insure that your primers are seated solidly and without excessive pressure will be rewarded by improved accuracy and performance of your reloaded ammunition.

Primer Sizes.

All commercial ammunition manufacturers make two different sizes of primers. There is a large size measuring ·210 inch in diameter that is adapted for rifle cartridges. This size of primer is also made for the larger calibers of pistol and revolver cartridges but the pistol primers, while the same size, are entirely different from rifle primers. Their cups are softer and thinner, so they will indent easily under the lighter hammer blow of hand guns and they contain pellets of a quantity and kind of mixture suitable to the ignition of fine grained and easily ignited pistol powders. They are not suited for use in rifle ammunition, even though they fit the primer pockets of such cartridges. The cups are too thin and they will not ignite hard grained rifle powders well. Their use in rifles is likely to result in pierced primers with their attendant danger to the aiming eye, in addition to their unsatisfactory performance.

On the other hand, rifle primers should not be used in pistol or revolver cartridges. They are too hot and strong for igniting pistol powders and may over ignite them, causing high pressures, also the harder or thicker cups offer too much resistance to the blows delivered by the firing pins or hammer noses of hand guns.

The small primer size is ·175 inch in diameter. Primers of this size are also made for both rifles and revolvers and the same remarks that apply to the large size primer apply to this size.

The uniformity of primer size in different makes of ammunition makes it possible to use primers of one make in cases of a different make and while there is no harm in using them interchangeably *with reduced loads,* provided they can be seated flush with or slightly below the heads of the cases, it is best to use primers of the same make as the cases, for reasons given above. This is especially true when reloading ammunition with full charges.

The two sizes of primers just mentioned are suited to all calibers of cartridges with three exceptions. The caliber ·45 automatic pistol cartridge *as manufactured by and for the U. S. Government* uses a special size of primer which is manufactured at the Frankford Arsenal. This primer is known as the Cal. ·45 number 70 Frankford Arsenal primer. It is ·204 inch in diameter and can only be purchased by N. R. A. members, through the office of the Director of Civilian Marksmanship, This size of primer cannot be used in any other cartridge than the ·45 Automatic. It will not fit *commercial* cases of this caliber, nor Winchester cases manufactured for the Government during the World War. These latter cases take the large size commercial pistol primers. The F.A. number 70 primer is a potassium chlorate primer and is *not* non-corrosive. It is, however, an excellent primer.

For a short time the Winchester Repeating Arms Co., manufactured ·30-06 ammunition taking a special large size primer ·225 inch in diameter and known as their number 225 primer. This was one of the first non-corrosive primers manufactured and is still obtainable, although now obsolete.

The third and only other exception in primer size is loaded in a lot of Peters Cal. ·30-06 ammunition made for the Government. This primer is the same, or about the same size as the F. A. Cal. ·45, No. 70 primer. As far as the writer knows, this primer cannot be obtained through commercial channels and none of the commercial primers will fit this particular lot of cases.

Note: ·32-20, ·38-40, and ·44-40 cartridges are used in both pistols and revolvers. When reloading them for rifles, use rifle primers but if they are reloaded for revolvers, revolver primers should be used.

Table of Primers.

MAKE	KIND	Large Rifle		Small Rifle		Large Pistol		Small Pistol	
		No.	Diam.	No.	Diam.	No.	Diam.	No.	Diam.
Remington.	N.C.-N.M.	8½	·210	6½	·175	2½	·210	1½	·175
	N.C.-N.M.	9½	·210						
Peters.	N.C.-N.M.	12	·210	65	·175	20x	·210	10	·175
	N.C.-N.M.	20 B	·210					15	·175
Winchester.	N.C.-N.M.	120	·210	116	·175	111	·210	108	·175
	N.C.-N.M.	115	·210					108 W	·175
		115½	·210					112	·175
	Chlorate	35	·210						
	N.C.-N.M.	225	·225						
Western.	N.C-N.M.	8½	·210	6½	·175	7	·210	1½	·175
	Mercuric	8½ G	·210					1½ B*	·175
Frankford Arsenal.	Chlorate	70 Cal						70 Cal	
		·30	·210					·45	·204

United States primers are identical with, and have the same numbers as Winchester primers.

* For black powder only.

Remarks:

N.C—N.M. indicates Non-Corrosive, Non-Mercuric.

The Chlorate primers listed are non-mercuric but not non-corrosive.

The Western No. 8½ G and 1½ B primers are mercuric and contain a corrosive mixture. The Western Cartridge Co. does not ship mercuric primers for reloading unless they are specifically ordered by number. In this case the mercuric primers are shipped it being assumed that the purchaser is familiar with their nature. The 8½ G primer is used in the Newton, ·300 Magnum and ·30-06 Match ammunition and is an excellent igniter but cases fired with it should *not* be reloaded with full charges.

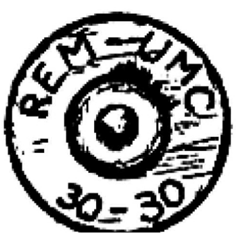
The Winchester No. 108 W primer is used in the small pistol and revolver cartridges such as ·32 S. & W. and ·32 Automatic. No. 112 is used in the ·38 auto and ·455 Colt. No. 108 takes care of all other cartridges using the small pistol size.

The Peters No. 20 B is used only in the ·38 and ·44 W.C.F. cartridges. The Peters No. 10 primer is now obsolete as are the Remington 8½ and Winchester No. 225.

Primers as a Means of Estimating Pressures.

It is useless to attempt to estimate chamber pressures by the degree of flattening of the primer. The newer non-corrosive primers are so violent in their action that they flatten nearly as much when fired with no powder at all, as when fired with the case full of powder.

Potassium chlorate primers, namely the Frankford Arsenal No. 70 and Winchester No. 35 NF (non-fulminate) will give more or less progressive flattening as the powder charges are increased, but even they are unreliable as a means of estimating with any degree of accuracy what the maximum chamber pressure is. The excessive flattening of any primer should always be heeded as a sign of high pressure, even though this flattening may be due to other causes. Pierced primers are a sign of high pressure, as are primers that leak or permit gas to escape around them.



SMALL LEAK

BAD LEAK

PUNCTURED PRIMER

CHAPTER THREE

POWDER.

Gun powder or Black Powder as it is often called, is the oldest propellant known for use in firearms. As made for small arms, it is usually a mixture of potassium nitrate, sulphur and charcoal. Sodium nitrate is used in place of potassium nitrate in blasting powders which, by the way, should not be used in small arms ammunition as the sodium nitrate makes the powder more violent in its action. It also increases the tendency of the powder to gather dampness and is more difficult to ignite.

Originally, gun powder was in fact a “powder”, the ingredients being simply ground up together, but for many years it has been made in a granular form. While none of our propellants are in reality “powders”, that name has been attached to propellants for fire arms for so long that it is inseparably associated with them. The composition of black powder varies only slightly in different countries, the proportions being about 75% potassium nitrate (saltpeter), 10% sulphur, and 15% charcoal. The nitrate and sulphur must be of exceptional purity and only a few woods are suitable for making the charcoal. As a boy, the writer used to make his own black powder of about a 60-20-20 mixture. The saltpeter used was the ordinary commercial product and undoubtedly contained chlorate, perchlorate or even chloride. The sulphur was ordinary drug store, powdered sulphur, which usually contains some sulphuric acid, and the charcoal, by the grace of God, was made from willow because it was found that willow charcoal would pulverize better

than some others. The charcoal was correct but it will be seen that about everything else was wrong, including the method of manufacture, which need not be gone into here. At the time, the product seemed to be a great success; it gave a loud report and produced much smoke but the manufacture of *good* black powder is no job for a child and requires much special equipment and above all, experience and skill. In some forms, its manufacture is baffling even to experts.

The process by which black powder is made may be described briefly as follows: The ingredients, of proper purity, are mixed together thoroughly and sifted. They are then "milled" or ground together in special stone or iron mills, with precautions to prevent friction or sparks, which makes a very fine and homogeneous mixture of the powder. It is next pressed into hard cakes or blocks which are dried and broken up to form the granules. These are graded for size by passing them through screens, which permit the largest permissible grains to pass through. The powder is caught on other screens that only permit the dust and grains that are too small to pass through. These grains are glazed by rotating the powder with graphite in closed cylindrical drums, after which the powder is again sifted to remove graphite and dust. The milling operation takes hours and this, as well as practically all other operations, are attended by danger of explosion unless special safety precautions are constantly observed. In fact, black powder is one of the most, if not the most dangerous of explosives to make, handle and store, because of the ease with which it can be ignited; a static spark may set it off and in loading it by machine there is a danger to a degree that does not exist when loading smokeless powders. On the other hand, black powder is the safest for handloading purposes. The proper method of loading it in any cartridge is to use a charge that will fill the case to a point where it will be compressed slightly, or packed by the base of the bullet when the latter is seated to the proper depth. An over charge is practically impossible if the proper size granulation is used.

Black powder, as supplied for reloading purposes, comes in three different granulations. FFFg is the finest and is used only in cartridges of small capacity. FFg is the medium size of granulation and has the widest application of the three. It is used in all medium size cartridges. Fg is the coarsest granulation and is suitable only for use in large caliber rifle cartridges.

It is said that when black powder is fired it gives off about 44% of gaseous and 56% of solid products; herein lies its great fault and lack of efficiency as compared with smokeless powders. The expanding gasses are the only part that causes movement of the bullet and the only way the velocity of a bullet may be increased with black powder is to increase the amount of powder that is burned behind the bullet, so as to produce more gas. The effort to obtain increased range and power in black powder cartridges can be seen from a study of the cartridges in common use about fifty years ago. The cases were continually being made with larger powder capacities to accomplish this result, but black powder, for sporting purposes, has largely gone into the discard in favor of the more efficient smokeless. The writer can remember when powder mills were fairly common establishments around the country and what ramshackle edifices they were. The practice was to build a stout skeleton framework of beams with a good strong roof with a flock of decrepit boards tacked on the sides. I believe the rule was not to use more than one nail to a board and for a very good reason. The workmen mixed the batches or prepared them for other operations and left the building. The machinery was started from outside, by remote control and was allowed to run for the proper length of time, after which it was shut off and the workmen returned. When, as occasionally happened, a "blow" occurred, the explosion followed the path of the least resistance and blew the building as clean of boards as a plucked chicken is cleaned of feathers. It was rare indeed for anyone to get hurt and all the boys had to do was gather up the boards, tack them in place, clean up the machinery and business went on as usual.

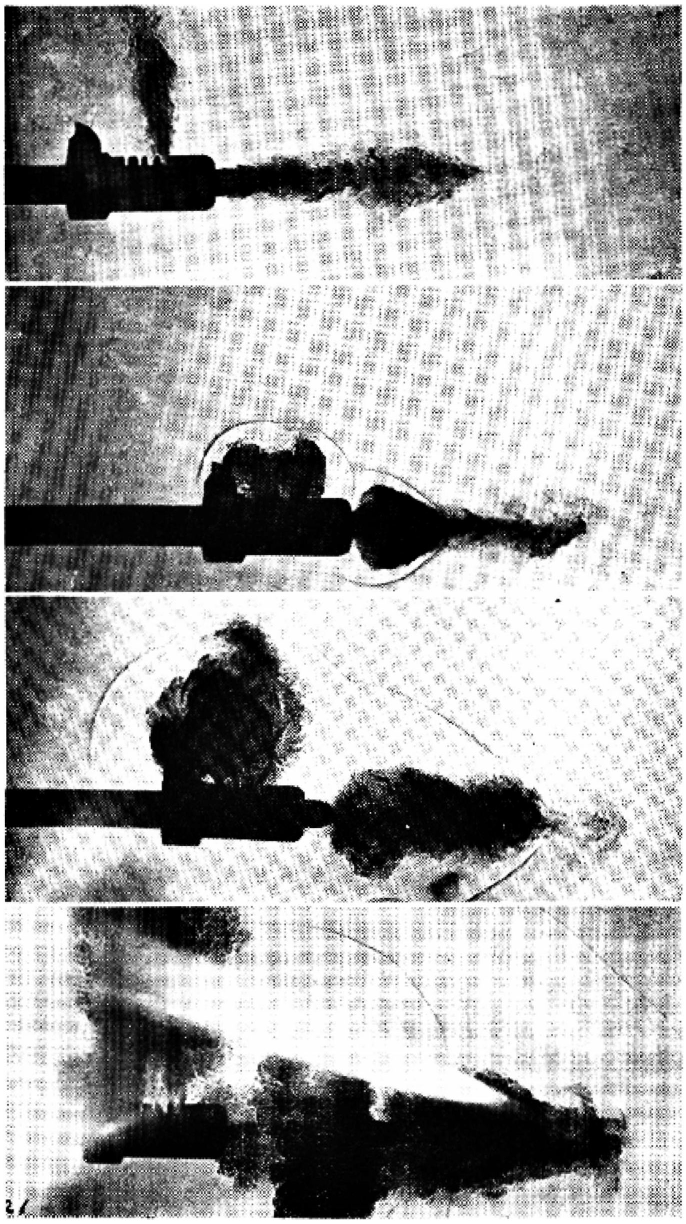
But to get back to the powder itself. Black powder gives a rather heavy recoil as compared with smokeless. This is due to the large amount of solids produced when the powder is burned; about 56% of the weight of the charge, which, from the standpoint of recoil, is just like adding that much weight to the bullet.

Recoil is divided into two parts; the primary recoil which is due to the velocity and weight of everything that goes out of the muzzle of the gun as opposed to the weight of the gun itself. The products of combustion and the bullet that leave the barrel are known as the ejecta and include the weight of not only the bullet and solids of combustion but the weight of the gasses as well. If the ejecta were equal in weight to the weight of the gun, the gun and the ejecta would leave each other at equal velocities when the gun was fired but, of course, guns are much the heavier of the two and consequently recoil at a very much lower velocity. The secondary recoil is due to the expansion of the gasses against the atmosphere, it also pushes the gun to the rear.

When smokeless powders are fired, they also decompose into gasses and solids, but the solids represent only a small percentage of the total and they develop a much larger volume of gas than an equal quantity of black powder. This means that they can give bullets a higher velocity than is possible with black powder and that they are relatively free from fouling and smoke. This means that the weight of the ejecta is less, which makes for a reduction in recoil, but the velocity of the ejecta is increased which partially offsets this.

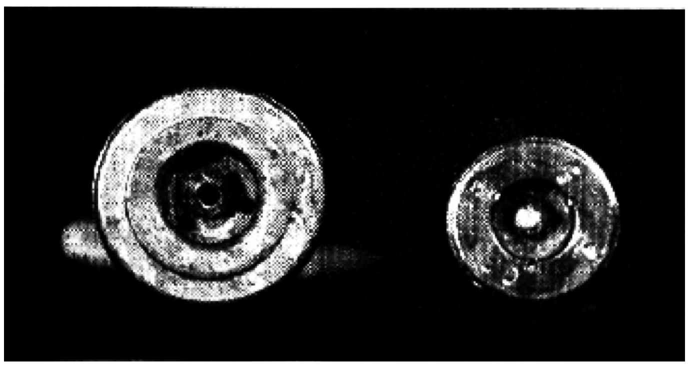
Smokeless powders are more difficult to ignite than black powder and when first introduced, the black powder primers then in use would not ignite it properly. It was common practice to place a small priming charge of black powder in the base of a cartridge before loading the smokeless powder charge, in order to get good ignition. The primer would ignite the black powder which, in turn, would produce an adequate amount of flame and heat to ignite the smokeless. This practice should *not* be followed in loading ammunition today, unless the circumstances are exceptional. With full charges of smokeless powders and modern primers, the addition of a black powder priming charge will increase the rate of burning of the charge over the expected point and can easily cause dangerous pressures. These priming charges may be used with reduced or low pressure loads but will rarely contribute anything to the performance of the ammunition.

Regarding the use of black powder in bottle neck cartridges, it can be used and if the barrel is kept clean, very good accuracy can be obtained with it. The objection to its use in these cartridges lies in the inability to compress the charge well, as the bases of bullets are smaller in area than the cross section of the powder charge. This will increase the fouling slightly but the principal difficulty relates to the large volume of powder in relation to the small bore. Remember that over half of the weight of the charge turns into fouling and smoke. A bottle neck cartridge of small caliber chokes the free passage of the products of combustion and not as much of it blows out of the muzzle of the gun as from a cartridge having a straight case, the inside diameter of which is approximately equal to the diameter of the bullet. A heavy deposit of fouling will quickly pack into the grooves of the barrel and render the arm inaccurate until it is cleaned out. For removing black powder fouling there is nothing better than water, and some very nice shooting can be done if the bore of the arm is wiped out with a wet patch after every few shots.

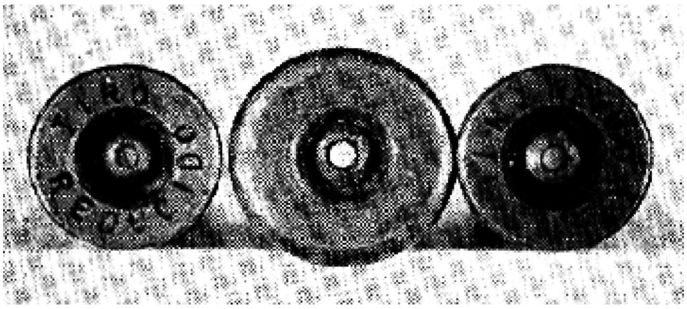


Series of spark photographs made by the late Capt. Philip Quale for Col. R. M. Cutts and published with the permission of the latter. These show how gas escapes between the expanded neck of the cartridge case and the bullet, before the latter starts forward. If the necks did not let go of those bullets first, how did that gas get out ahead or them?

PLATE VII.



Berdan Primer Pockets.
The case on the left is an old Sharp's folded head case. The one on the right shows the conventional form of anvil and is of recent manufacture.



Berdan primer pockets with central flash hole through the anvils to permit pushing fired primers out. The center case is an old ·40-90 Ballard case, probably over 50 years old. The cases flanking it are of recent manufacture.

PLATE VIII.

Semi-Smokeless Powder

Semi-smokeless powder is a mixture of black and smokeless powders, the two being incorporated during the process of manufacture. One doesn't hear much about it, but it is probably the best of all powders for a reloader to begin on and it is unfortunate, that the manufacturer does not advertise it more widely. It is made in a variety of different granulations and can be used in all cartridges whether straight, tapered, or bottle-neck and in all calibers of rifles, revolvers and even shotguns. It does not leave the heavy fouling of black powder and while not as clean burning as smokeless, one can, nevertheless, fire long series of shots with it without fouling the barrel enough to affect accuracy. It may be measured with perfect safety with dip measures and is usually loaded in the same volume as black powder, although it is not advisable to compress the charges as with black powder.

Semi-smokeless charges, while of about the same volume as black powder charges, are much lighter in weight, as black powder has much the higher specific gravity of the two. The only possible danger in loading semi-smokeless lies in over-compressing charges or using a finer granulation than that recommended for the cartridge being loaded. If you cannot get the granulation you want or have some on hand that you wish to use up that is not of the proper granulation for the cartridge being loaded, use a coarser granulation rather than a finer one. If a finer granulation is used, the charge should be cut down about ten percent. This is a good safe rule to follow, even though it is not necessary to do so with all cartridges.

Semi-smokeless powder is manufactured by the King Powder Co., Kings Mills, Ohio. It is moderately priced and can be shipped by express anywhere in the United States. The manufacturer can supply leaflets with tables of charges showing the correct granulation for all calibers of cartridges. Because of the simple method of loading and the nature of the powder, semi-smokeless is useful in loading odd calibers of European cartridges for which no smokeless powder loading data is available in this country. To select the proper granulation for such a purpose, compare the foreign cartridge with the nearest American cartridge to it in caliber and capacity, then get the powder recommended for the American cartridge. If your cartridge is a little larger in caliber or holds more powder than the American cartridge nearest to it, use the next larger granulation of semi-smokeless powder. For making comparisons, an ammunition catalogue will do as the illustrations in these catalogues are usually made the actual size of the cartridges.

Lesmok Powder.

It is unlikely that anyone who reloads ammunition will ever run into any of this powder but if the reader should by chance come into possession of any of it, get rid of it quick. By getting rid of it I mean dump it on the ground and burn it, or throw it in the creek. This powder is used today in loading ·22 caliber, rim-fire ammunition and it is probably the most dangerous powder to load that there is. Lesmok powder acts like semi-smokeless with respect to the fouling that it leaves in the bore of a firearm but that is as far as the similarity goes for Lesmok is a mixture of black powder and GUN COTTON. It ignites easily and can be fired by friction or by a blow. Even in the hands of those thoroughly familiar with it in the ammunition plants, flare-ups occur with it and it is only because of special precautions and safeguards that these are not serious.

Smokeless Powder

This is the type of powder that is most widely used for handloading ammunition as well as in ammunition manufacture. Any reloader who can follow simple directions and who is willing to stick to the more moderate charges of powder can use smokeless powders with safety and entire satisfaction, but when using full charges or departing from recommended loads in any detail, one's knowledge of powder cannot be too complete.

Smokeless powders, unlike black powder, are chemical compounds rather than mechanical mixtures. No two powders are alike and as the chemical reactions and combinations that take place during the manufacturing process cannot be controlled exactly, there is often a considerable difference in the performance of two batches or lots of the same powder. The power of powder is dependent upon the amount of nitrogen that it contains. In black powder, the nitrogen is contained in the potassium or sodium nitrate that forms a part of it. As these substances can be accurately measured and as their nitrogen content is definitely fixed, it is possible to get the same amount of nitrogen into each batch of powder. This is not true of the manufacture of smokeless powder, the body of which is nitrocellulose. Nitrocellulose, as used in American powders, is cotton waste or linters nitrated by treating with nitric and other acids. After nitration, the acid is washed out by boiling in changes of water for several hours. The water is removed from the nitrated cotton first by centrifugal wringing, then the remainder by forcing alcohol through the wet cotton, the alcohol displacing the water.

The nitrocotton is then reduced to a plastic gelatin-like condition by the use of suitable solvents in mixing machines during which process the stabilizing agents, salts, or deterrents are incorporated. Much of the solvent used is recovered and used over again.

The amount of nitrogen taken up by the cotton depends upon the strength of the acids used, as well as the length of time the cotton is exposed to the nitration treatment. Some of the nitrogen taken up by the cotton is lost in the later washing and boiling purification process. Large blends of the nitrated cotton are made so that the average nitrogen content is virtually the same from lot to lot.

The gelatinized nitrocellulose is squeezed through dies and formed into strings of a size suitable for the ultimate purpose the powder is to serve, either as a solid string or with a small hole through the center, after which it is cut into grains of the proper length and dried.

Smokeless powders are divided into two classes; nitrocellulose or single base powders which are of nitrocellulose with a stabilizer salts, deterrent, etc, and nitroglycerine or double base powders which are made from nitrocellulose also but with nitroglycerine added, with or without a stabilizer or deterrent. A stabilizer is an agent used to arrest any chemical action in the powder so that it will not deteriorate rapidly in storage; diphenylamine or crude vaseline being used extensively for this purpose.

There has been much argument over the relative merits of nitrocellulose and nitroglycerine powders, it being claimed that the latter are much more erosive than the former. This is probably true with powders containing a large percentage of nitroglycerine because of the high burning temperatures developed, but if the quantity of nitroglycerine is not large, there is little difference in the erosion caused by the two types of powder. When used in reduced loads, neither of these powders are erosive. In making nitrocellulose powders, it is impossible by any practicable means to recover or drive off all the solvents and anyone opening a fresh canister of nitrocellulose powder will readily detect the strong odor of ether. The remaining volatiles, or solvent in the powder, will gradually evaporate and will do so more rapidly if the powder be stored in a warm place. This changes the ballistic properties as the solvents act as a deterrent and their loss consequently somewhat speeds up the burning rate of the powder and higher pressures will result. The reader should not be alarmed at this statement as our nitrocellulose powders will stand long storage under proper conditions.

Nitroglycerine powders, on the other hand, use a smaller amount of acetone solvent because of the solvent power of the nitroglycerine, and hence the grains are not apt to change due to solvent loss, no matter how long the powder is stored. Nitroglycerine powders are the easier of the two to ignite, they burn a little more uniformly, and because of their higher nitrogen content are more powerful, which means that they can be used in smaller charges than nitrocellulose powders to develop the same ballistics. Because of their ease of ignition, nitroglycerine powders are not so susceptible to primer faults as other powders. The reader may suspect that I am prejudiced in favor of nitroglycerine powders. I am and because I have always been able to get just a wee bit better results with them. It should be borne in mind, however, that one person's opinion doesn't prove a thing, nevertheless, it is perhaps significant that some of the new line of duPont powders contain nitroglycerine. And this after the long years that the duPont boys have preached about the horrors of nitroglycerine in powders, years, by the way, during which the duPont Co. made nothing but nitrocellulose powders. Well, they are nice boys just the same and the new powders are excellent.

For many years much has been made of the erosive properties of nitroglycerin powders. It is true that nitroglycerine powder is more erosive than nitrocellulose powders but only when the nitroglycerine content is high. This is largely due to misunderstanding, and the fact that the corrosive effect of the older type primers was generally attributed to the erosive properties of the powder instead of to the primers where the fault actually lay.

Glycerin is just one of many substances that will take up nitrogen when treated with nitric acid. When nitro-glycerin is added to nitro-cellulose it simply increases the potentiality or nitrogen content of the resultant powder. If two charges of powder of equal volume, one containing nitroglycerin and the other being of straight nitro-cellulose, are fired in the same chamber under the same conditions, the powder with the higher potential will develop the greatest amount of heat. As heat is closely related to the subject of erosion, the powder of the higher potential will be the most erosive. This forms the basis of the statement that nitro-glycerin powders are more erosive than nitro-cellulose powders, but the hitch comes in that the two kinds of powder are not loaded in equal volume. Because of the higher potential of double base powders, smaller charges of them are required than single base powder to impart a given velocity to a bullet, and the pressures developed by the double base powders are frequently less than those that must be developed by a straight nitro-cellulose powder to obtain the same velocity. As the heat, or burning temperature produced, is influenced by the chamber pressure a double base powder will sometimes develop less heat and consequently be less erosive than a straight nitro-cellulose powder. The mere fact that a powder has nitro-glycerin in it means nothing in itself as far as erosion is concerned. The whole matter is one of potential or nitrogen content and it is possible to produce a nitroglycerin powder of lower potential than a straight nitrocellulose powder.

The duPont Company has for many years been identified with the manufacture of straight nitro-cellulose powders. Their new line of I.M.R. Powders are of this class and are excellent. Their new Pistol Powder No. 6. however, contains a small percentage of nitro-glycerin and this powder, because of its easier ignition and more uniform burning, is a considerable improvement over the now obsolete single base Pistol Powder No. 5.

The manufacture of nitroglycerine powder differs from the manufacture of nitrocellulose chiefly in the addition of the nitroglycerine. The proper amount is added to the dry nitro cotton, which is afterward worked thoroughly in a mixing machine. The mineral jelly or stabilizer is added while the batch is being mixed with the solvent, as with straight nitrocellulose powder. The general manufacturing process is the same for both and as this book pertains to the reloading of ammunition rather than to the manufacture of powder, the details of the process of making powders is purposely omitted.

Rate of Burning. Uniform ballistics or uniformity from one shot to another, can only be obtained by a uniform rate of burning of the powder. The rate of burning of any powder is therefore of the utmost importance in obtaining good accuracy and as the burning rate, especially of smokeless powders, is not fixed entirely by the composition of the powder itself, it is important that the handloader understands something of this.

If some black powder is ignited in the open air, it will burn with a quick flash, while smokeless powder burned in the open is consumed slowly. The rates of burning of these two classes of powder, when burned in the open, are obvious. When smokeless powder is loaded into a small arms cartridge and fired in the usual way, it burns quickly, therefore the rate of burning of smokeless depends upon the degree of confinement under which it is burned and this degree of confinement varies with the caliber and shape of the cartridge case and the amount of powder used, as well as a number of other things. In order to get this matter of rate of burning more firmly fixed in our minds, let us consider another simple example.

If a dry piece of string a foot long be ignited at one end, it will burn slowly until entirely consumed. Now, if we take a strip of pure nitrocellulose the same length as the string and ignite one end of it, it will be found to burn more rapidly than the string but, like the string, it will burn progressively from one end to the other. If a one foot strip of nitrocellulose having nitroglycerine incorporated in it is burned, it will be consumed more rapidly than either the string or the pure nitrocellulose. In short, the three substances have different rates of burning. The rate of burning is merely the speed with which any substance is consumed by burning and is usually measured in feet or meters per second. It is governed by the amount of oxidizing agents present or, in other words, the amount of the substance that turns into oxygen when decomposed. It so happens that nitroglycerine is the only organic explosive that contains more oxygen than is necessary to burn it completely when excluded from the air and its incorporation in powder helps the combustion and increases the rate of burning, therefore, nitroglycerine powders burn more rapidly than nitrocellulose powders, all other things being equal. There are ways of controlling the rate of burning of powders other than by their chemical composition, as we will see presently.

Getting back to our strips of powder, if twelve one inch pieces of powder are all ignited at the same instant, they will be consumed in one twelfth the time required to burn a single strip one foot long. Twenty-four one-half inch pieces will burn in one-half the time required to burn the one inch pieces, etc. Therefore, the burning time is also affected by the size of the pieces of powder and the area that is ignited. The rate of burning is also affected by, not only the size of the pieces or grains of powder, but by their shape as well.

When a cartridge is fired the powder charge "explodes," the explosion being nothing more than rapid combustion or burning of the powder. In burning, the outer surfaces of the grains are consumed first, the grain decreasing in size as successive layers are consumed until the grains are entirely consumed. No matter how fast the powder burns, it always burns towards the center of the mass. Combustion is the oxidation of a substance and burning is rapid oxidation and is accompanied by the production of heat, and the rate of burning influences the heat or temperature produced. By way of example, we can consider a piece of wood. If exposed to the elements for a period of time it will decompose or rot. If ignited, it will decompose by burning, but the decomposition will be rapid and accompanied by the production of heat. The decomposition is, in both cases, due to oxidation and, believe it or not, the heat produced in both cases is the same. In the process of decay, the heat is given off so slowly and is so quickly dissipated that there is no measurable rise in temperature, as when burning takes place, and likewise, in both cases the decomposition starts on the outer surface and works toward the center of the mass.

Up until 1860 gunpowder was used in solid granular form, or for artillery was pressed into solid blocks or cakes of various sizes and shapes. Powder of any kind burns from the exposed surface toward the center of the mass and the work that it can do depends upon the amount of gas given off. The area of a solid grain of powder is reduced and the grain becomes smaller and smaller until it is entirely consumed, consequently it will give off the greatest volume of gas at the instant that the entire surface is completely ignited. When burned in a closed chamber, the expanding gasses build up pressure that in turn forces the bullet or projectile forward. One of the laws of moving bodies having weight is that they cannot be set in motion except at the expense of time and even after the chamber pressure is above that required to overcome the weight and inertia of the bullet and impress it into the rifling of the barrel, a certain amount of time is required to accomplish this. After the bullet once commences to move, the space in which the gasses are expanding continually and rapidly increases, as the bullet moves along the bore. This additional space relieves the chamber pressure and it is desirable to have the gasses reach their maximum pressure after the bullet is in motion. The ideal condition would be to have the pressure rise gradually until the bullet starts to move and to continue to rise, accelerating the bullet all the way to the muzzle of the arm. This would develop tremendously high velocities but it is impossible of accomplishment. On the contrary, the thing that must be avoided is having the pressures rise so rapidly that they exceed safe limits before the bullet has time to move, or to move far enough to leave enough space behind it for the gasses to expand in with safety.

Black powder is porous and if burned at too high pressure, the gasses will be driven through the grains causing almost instantaneous ignition and dangerous pressure, Smokeless powders, because of their close grained and horn like nature will stand higher pressures than black powder, but there are limits to the pressures that even they will stand.

As solid grains of powder evolve the most gas at the instant their entire outer surface is aflame, it stands to reason that in a closed chamber they develop the maximum pressure at this point. Powder charges do not ignite throughout at once. The primer ignites the rear of the charge, more or less of which burns, causing the development of heat and pressure which ignite the remainder of the charge and accelerate the burning. We have seen by comparison that the pressure under which powder burns affects its rate of burning by comparison with powder burned at atmospheric pressure and when fired in a gun; the higher the pressure, the faster the burning. Consequently, the rate of burning and the rise in chamber pressure is a progressive and accelerated phenomenon, each promoting the other. With solid grained powders the maximum pressure is reached quickly and the rapidly decreasing burning area of the charge causes it to fall off rapidly.

In the year 1860, Col. T. J. Rodman conceived the idea of making artillery powder in the form of large washers that would just fit the chambers of the guns it was to be fired in. His theory was, that if the inside of the washers were ignited, the burning area of the charge would *increase* and there would be a constantly *increasing* volume of gas to accelerate the projectile which would increase the muzzle velocity; and practice bore out the theory. The form of the pressed powder soon changed but the principle was maintained and this was the forerunner of our present perforated powders. These powders burn both from the inside and the outside at the same time and as the outside area decreases, the inside area increases. Once a charge of tubular grained powder is fully ignited, the rate of burning is much more even than with solid grained powder but the grains burn from the ends and constantly decrease in length and it, like any other powder, is subject to the influence of the increased burning space due to the movement of the bullet. That tubular powder does burn from the inside as well as the outside is easily proven with a piece a couple of inches or more in length, such as Cordite, used by the British Army. Light one end of it and, by blowing hard, the fire on the outside can be blown out but the inside will continue to burn. Another example of this can be found in artillery powder which has a number of holes through it. When such

powder is fired, the area of all the holes increases until they meet and the little triangular pieces that are left are blown out of the gun. They can usually be found on the ground out in front of the gun and are known as "powder slivers."

By using perforated powder grains it was possible to get higher muzzle velocities than formerly because the more uniform burning gave a more sustained pressure and greater acceleration to the bullet, but the maximum pressure was still reached after the bullet had moved only a very short distance along the bore. Ballisticians were (and still are) working to delay the initial rate of burning of the powder until the bullet has moved further forward before "giving it the gun" in the form of accelerated burning of the charge and a greater gas volume. The increased space provided by the movement of the bullet would permit this to be done without causing dangerous pressure, but the trick was to do it. A considerable amount of progress has been made along this line since the World War. Some powders are now coated or impregnated on the surface with substances that slow up their initial rate of burning. These powders are a little harder to ignite than plain burning powders but the surface of the grains burns slowly, relatively speaking, and builds up the chamber pressure more slowly, giving the bullet more *time to* move forward and allowing it to move farther forward before the flame reaches the un-impregnated and fast burning part of the grains. The greatest liberation of gas occurs after the bullet is in motion and while the position of the bullet at the time the highest pressure is reached, has only been advanced a fraction of an inch by the use of coated powders, even this small amount has resulted in a great increase in muzzle velocities.

It is unfortunate that the factors influencing the rate of burning of powder, and especially of smokeless powder, cannot be explained in a few words but the phenomena are so involved and inter-related that it is difficult to explain some of them at all. The factors thus far discussed that affect the rate of burning may be summed up as follows:

1. The chemical nature of the powder itself.
2. The physical nature of the powder. (Hardness or porosity).
3. The degree of confinement under which it is burned.
4. The pressure under which it burns. (Related to confinement and temperature of burning).
5. The temperature of burning. (Related to confinement and pressure).
6. The size of the powder grains.
7. The shape of the powder grains.
8. The strength and heat of the primer.

Practically all of these factors represent things over which the handloader has no control whatever and the discussion of them therefore becomes purely academic. But there is one of them that can be and must be observed and controlled when reloading ammunition. I refer to the confinement of the charge.

Density of Loading. The relation of the volume of the powder charge to the volume of the chamber it is fired in is called the density of loading and the more nearly equal the two become, the higher the density of loading is said to be. The two things that increase the density of loading or confinement of the charge when reloading ammunition are: an increase in the quantity of powder used, and increasing the depth of seating of the bullet. The increased confinement alone from either of these causes will cause greater pressure to be developed in the chamber, to say nothing of that caused by the additional gas liberated by the heavier charge of powder. When loading full charges of powder in any cartridge, any increase in the seating depth of the bullet over the recommended depth of seating should be accompanied by a corresponding decrease in the volume of the powder charge. With reduced charges, the depth of seating of the bullet is not important from a safety standpoint, provided the reduction in the charge is sufficient to off-set the additional space occupied by the bullet. These two factors are not exactly in direct proportion, as any decrease in the charge is accompanied by a reduction in the total amount of gas given off, but a handloader will never get into trouble by considering them as directly proportional.

Some cartridges have a low density of loading normally. The revolver cartridges, most of which were designed to use a large bulk of black powder, are examples of these. Loaded with smokeless powder, the charge occupies only a small part of the cartridge and with any normal charges and bullets, the depth of seating of the bullet is not critical and can be increased slightly if necessary. When, however, deep seated wad-cutter bullets are used, the confinement of the charge becomes too great and must be compensated for by a hollow in the base of the bullet, a reduction in the powder charge, or both.

Two other factors that affect the rate of burning and which may be listed in continuation of those previously mentioned are:

9. The volume of the powder chamber in relation to the sectional area of the bullet.
10. The shape of the powder chamber.

The sectional area of the bullet is directly related to the caliber. Because of the differences in volume and shape of different cartridges, the powder charges recommended for one will not give the same ballistics in another cartridge even though the other cartridge is of the same caliber. Likewise, if two cartridges had the same powder capacity and used the same bullets, charges would not be interchangeable in them because of differences in the shapes of the chambers for them. I know of no two cartridges in which this condition exists, outside of a few experimental ones and the comparison is offered only as a hypothetical one. Even a change in the angle of the shoulder of a bottle-neck cartridge is sufficient to cause a considerable difference in the way the powder charge burns. By change in angle of the shoulder, I mean a deliberate and appreciable reforming of the shoulder and not any slight change that may take place when the case expands to the limits of a normal chamber.

Tolerance and Balance Point. If all powders burned exactly alike and burned uniformly regardless of chamber volume, caliber, bullet weight, etc., we would only need one powder for loading all calibers of cartridges. But they don't. Each powder has its own peculiarities and limitations of use, for reasons already explained and each one has a point in its pressure curve at which it burns best. This point is called the balance point.

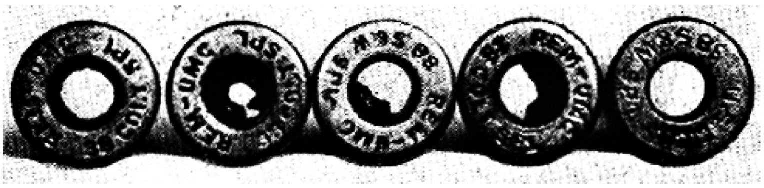
When, for example, the bolt of a rifle is being designed, its outside diameter is fixed at a dimension that will permit it to work freely back and forth in its receiver. As it is very expensive to make mechanical parts to exact dimensions, some allowance must be

made for slight variations that are bound to occur in commercial production, due to wear of the tools, etc. It is necessary, therefore, to establish the maximum diameter of the bolt at a point where it will not stick or fail to operate and the minimum diameter so it will not be a loose and sloppy fit. This gives the workman a little latitude to work in and still produce a satisfactory bolt. The permissible variations above and below the standard, or ideal, dimension are known as the tolerance. It is just so with smokeless powders and each one of them has a limit of pressure above and below the balance point, within which they will burn efficiently and uniformly and this range of pressures is also called the tolerance.

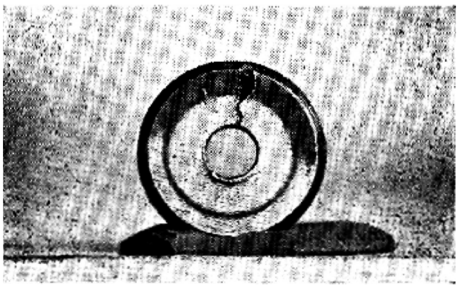
If a powder is burned at a pressure below the lower limit of its tolerance, it may fail to burn uniformly and this will cause variations in velocity and poor accuracy. Even though the burning is fairly uniform, it may not be complete and part of the powder may break down into products that are injurious to the barrel. If the nitrates are not consumed, they can gather atmospheric moisture and form minute quantities of nitric acid which will cause rapid rusting, regardless of any magic non-corrosive primers. It is bad business to burn powders at pressures below the lower limits of their tolerances, but it is not unsafe.

As pressures approach the upper end of the tolerance, the pressures are still safe, even though they may be high, but they are approaching a pressure level at which they will burn erratically. The upper limit of the tolerance does not represent a point which, if exceeded slightly, will cause bursting pressures. It does represent a point beyond which the pressure developed cannot be predicted with any degree of certainty. When this point is exceeded and whether the excess pressure is due to too much powder, too hot a primer, too large or hard bullet, or a bullet that is too heavy or too deeply seated for the charge, the pressure and velocity will become erratic. Loads developing pressures toward the upper limit of the tolerances are known as “maximum *permissible* loads”. They are not to be confused with *maximum* loads, about which more and very bad things will be said later. Erratic pressures are jumpy, uncertain pressures. A person may exceed the maximum permissible load for a certain powder and cartridge and apparently get away with it, shooting his ammunition in blissful ignorance of the way the pressures are jumping around. Then, for no apparent reason, one goes sailing up to the sky and he finds himself with his rifle in two pieces, one in each hand. Or maybe somebody else finds him. “Why! I can't understand it! I have been using that load for two years and am *very* careful about loading it—weigh the powder and bullets 'n everything!” Have you ever heard it? Of course he can't understand it. If he knew enough about powder to understand it, he wouldn't have used the load in the first place.

The tolerance of a powder, unlike that of the rifle bolt referred to previously, must be determined *after* the powder is made. When a new lot of powder is made, a charge, pressure and velocity curve is established to determine its ballistic properties. Assuming that the new powder is an attempt to duplicate a previous lot, the ballistic records of the previous lot are referred to as a guide to the selection of a charge to start with. From three to five cartridges, depending upon the caliber of the cartridge, the practice of the laboratory, or expediency, are loaded with a very moderate charge and are fired for pressure and velocity. The mean or average of the pressure and velocity readings for this series of shots are plotted as two points on cross section paper. These results are compared with the firing data of the previous lot for similarity, or lack of it, and another somewhat higher charge is determined upon for the next series of shots, the mean results of which are plotted as a second pair of points.



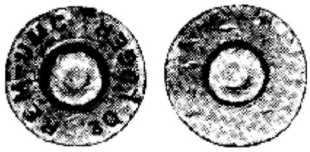
·38 special cases with folded heads which have had the webs cracked and blown away. This is a serious fault in fired cases and should be watched for. It permits an excessive pressure to reach the primer, driving it back violently against the recoil plate of the revolver and may damage the latter.



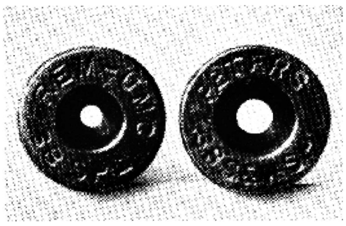
A revolver recoil plate which has been cracked by the primer set-back from high-pressure loads or cases having enlarged flash-holes.

PLATE IX.

An automatic pistol case which has been fired to destruction with mercuric primer. Originally fired with a mercuric primer, it was then reloaded and fired three times with non-mercuric primers—with the result shown above.



These cartridges fired prematurely from the slam of the breech block because the primers projected slightly above the case heads. Note the mark of the firing pin hole and the absence of firing pin indentation.



An extreme example in variations in vent sizes as described on page 27.

PLATE X.

This process of gradually increasing the charges, loading and firing a series of shots and plotting the pressure and velocities obtained, continues until the maximum permissible pressure for the cartridge is reached, or the pressures become erratic. Rifles can be mounted as pressure gages for routine tests but for experimental work with powders of unknown characteristics, special heavy guns are used that will withstand tremendous pressures.

The result of this firing leaves a sheet of cross section paper with two series of dots on it; one representing pressures in relation to the weights of charges and the other representing velocities, also in relation to the weights of charges. Velocities can be taken quite accurately and the velocity points will represent quite an orderly progression. The ordinary method of taking pressures is somewhat crude, though satisfactory, and points representing pressures, when connected by straight lines, bear more resemblance to a portrayal of lightning or an Indian tepee than they do to a curve, so these "curves" must be smoothed out. This is done by drawing a regularly curved line that will, without breaking its regularity, pass through as many of the dots as possible. (See frontispiece.)

If the loads first fired were below the tolerance of the powder, the dots or points representing the "curves" will vary up and down. If the firing is carried beyond the upper limit of the tolerance, the points will vary up and down, but their general course will represent a decided flattening of the pressure curve all out of proportion to the flattening of the velocity curve. The higher pressures go, the smaller the increase in velocity for each increase in the charge. In the pressure curve there will be a range where the plotted points will coincide quite well with the smoothed out curve. This uniform range represents the tolerance of the powder and the point of the greatest uniformity is the balance point. The tolerance may be wide for one powder and narrow for another, but, that is the way the job is done. In making up tables of charges, the powder companies must establish curves, not only for each powder but for every cartridge that those powders are used in and for each different bullet as well. It can be seen that there is an immense amount of work, to say nothing of expense, in back of every one of these tables. We handloaders are indeed fortunate in having such authentic and complete data available for the asking.

In the acceptance tests of military powders, the charge, pressure and velocity curve must show that the powder being tested will develop the proper velocity in the cartridge and with the projectile specified, without exceeding the permissible pressure. The velocity that the projectile must have and the maximum permissible pressure for the guns the powder is to be fired in, are fixed in the specifications and the powder must meet those specifications or it will be rejected. This is necessary because the military requirements of the ammunition are such as to necessitate a uniform muzzle velocity from one lot of ammunition to another.

This need for rigid powder specifications does not exist in commercial sporting ammunition except in a few special instances. Consider our own military requirements for powders for small arms ammunition; we have only three calibers, ·30, ·45 and ·50 and we

could get along with only three different powders if we had to. Now in comparison, just take a look at the variety of cartridges, different weights of bullets with which they are loaded, etc., in any ammunition catalogue. Each one of those cartridges presents its own loading problems and the range is so great that the commercial manufacturer *needs* a variety of powders of widely different burning characteristics. Even though a new lot of powder may not burn properly in the range of cartridges it was manufactured for, its burning characteristics may be exceptionally good when fired in a different range of cartridges than that for which it was intended. For example, a powder made for the ·30-06 cartridge may, on test, be found to develop too high pressures, which indicates that it burns too quickly for the ·30-06 and that when tested in the Cal. ·250-3000 cartridge it gives high velocities with perfectly safe pressures. The commercial manufacturer has all the necessary laboratory equipment for determining the suitability of powders for his loading requirements and can use lots of powders that are "off" from the standard, very nicely. For this reason there is no certainty as to the kind of powder that is used in different lots of any caliber of commercial cartridge and commercial ammunition is subject to wider variations in velocity from one lot to another than military ammunition. The manufacturer endeavors to load as closely as possible to the advertised velocity but the primary objects sought are satisfactory performance and safety.

The Measurement of Pressures.

Here in the United States pressures are customarily measured by what is known as the radial system. A heavy steel yoke is mounted around and over the chamber of the barrel in which the pressures are to be taken. A hole is drilled through the base of the yoke that encircles the barrel, into the chamber. A steel piston is closely fitted to the hole, with just enough clearance so it may move up and down freely. A heavy thumb screw passes down through the top of the yoke and a steel block, called the "anvil", is made to fit loosely inside of the yoke. The fit of the anvil is such that it can be readily removed and replaced and its upper and lower surfaces are ground smooth and parallel. This constitutes the mechanical part of the gage. Pressure gages for rifle cartridges usually have the piston located one inch from the head of the cartridge but for revolver and pistol cartridges the pistons are located just ahead of the front edge of the cartridge case.

A small copper cylinder called a "crusher" is used to measure the pressures developed within the chamber. These crushers must be of uniform hardness, or more properly, softness, as it is upon their uniformity of viscosity that the uniformity and accuracy of the readings depend. The method of using a crusher gage is as follows. A cartridge is placed in the chamber and a gas check cup, similar to a gas check used on a cast bullet or a primer without an anvil, is filled with grease and inserted in the piston hole, base up. The piston is inserted on top of this and pressed down until the edge of the gas check is in contact with the cartridge. The gas check and grease serve to prevent the escape of gas past the piston. A crusher is placed on it, first having been carefully cut to length and measured with a micrometer caliper, end on top of the piston and the anvil on top of the crusher. The thumb screw is turned down so as to bear firmly on the anvil, but not with a pressure that will disturb the dimensions of the crusher. This thumb screw, through the anvil, supports the thrust of the crusher when the gun is fired. When the cartridge is fired, the internal pressure, acting radially against the chamber walls, also acts upon the piston of the gage, forcing it upward and compressing the crusher. The crusher is then removed and measured again to determine the reduction in its length and the amount of reduction is used as a measure of the maximum pressure developed in the chamber. The pressure is expressed in terms of pounds per square inch, but actually it is nothing of the kind. This method is crude and has many faults but it is convenient and affords sufficient accuracy to insure the loading of safe ammunition. The figures obtained vary considerably, for many reasons that need not be explained here and are subject to interpretation by those whose experience makes them competent to do so. The average person is apt to consider the numerical values of pressures, expressed in terms of pounds per square inch in powder charge tables, as fixed values of measurement in the sense that a one pound weight or a foot rule are fixed values. This is a mistake and other than to indicate a maximum point beyond which charges should not be used, they are of no particular value in tables of charges.

One thing a crusher gage does not show is the *time* required for the pressure to reach its maximum point. If the pressure is close to the bursting point of a gun, this element of time is of great importance for if the maximum point is reached too quickly, the molecules of the steel will not have time to adjust themselves to the strain and the gun will burst. As an example of the effect of the element of time on applied force, a simple experiment can be made with a piece of ordinary tar. At room temperature the tar is quite hard, but it may be slowly bent or deformed with the hands. All that is necessary is to apply the force slowly enough so that the molecules can adjust themselves to it. But if we strike the tar a sharp quick blow it will break, because the force is applied so quickly that there is insufficient time for the molecules to readjust themselves, although the energy of the blow may be even less than that previously applied with the hands. It doesn't pay to experiment blindly with powder charges when the pressures are around the upper limits of the tolerance, nor is it necessary to do so. Both the duPont and Hercules powder companies are willing to assist re-loaders who desire to experiment with unknown loads and will make pressure determinations for them at a very reasonable charge; about one dollar per shot, if I remember correctly. This may seem like a lot of money, but the reader should bear in mind that it costs around two hundred dollars to make a pressure gage and the life of one of these gages is only from about two hundred or less shots up to five hundred at the most. From this it will be seen that the charge made hardly more than pays for the wear and tear on the gage.

The Measurement of Velocities.

The speedometer of an automobile, as its name indicates, registers the speed in miles or kilometers per hour that the car is traveling at, at any particular time. If we wish to determine the average speed of the car between any two points, a speedometer is useless and we must use a time piece, taking the time of departure, the time of arrival and dividing the elapsed time by the number of miles traveled; for under ordinary driving conditions, it is impossible to drive a car at a uniform rate of speed.

Bullets have no speedometers on them, nor do they travel at a fixed rate of speed and their velocities must be measured with an instrument that measures time; the time required for the bullet to travel over a known distance. To measure the velocities of bullets and projectiles, instruments known as chronographs are used, their name signifying the graphic measurement of time.

The instrument most used for this purpose is the Boulenge chronograph, the invention of a Belgian army officer whose name it bears. This chronograph has been modified in several ways during the many years it has been used but the fundamental principle is

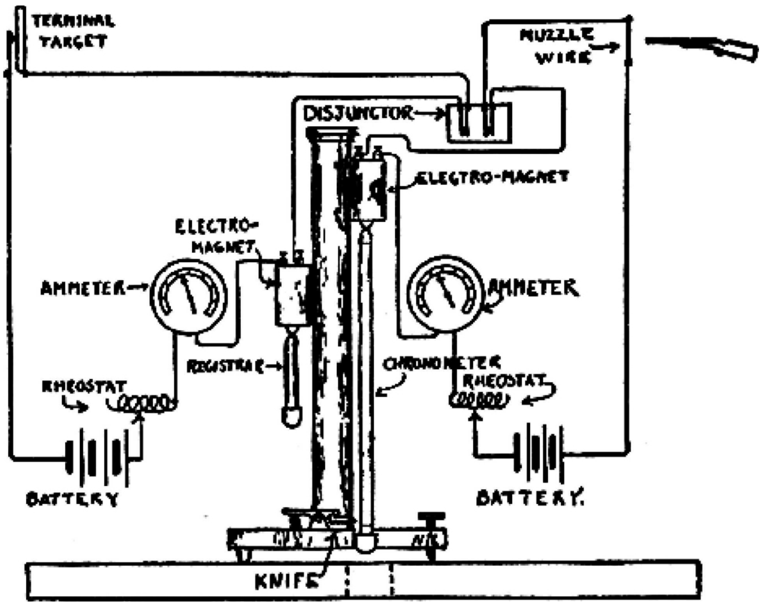
still retained, viz.; the measurement of elapsed time through the medium of two falling weights. The design and operation of this instrument can be understood from the accompanying simplified diagram.

The instrument consists of a solid base mounted on legs that can be adjusted to level it and set on a solid bench. The base supports a substantial vertical column about three feet high to which are attached two electro-magnets, one higher than the other. The circuits for these two magnets are independent of one another but a means is provided interrupting both circuits at the same instant, in order to obtain a zero point. This device breaking both circuits at once is called the "disjunctor." Their cores are, of course, only magnetized while the electric current is passing through them and must be uniform as to magnetic "lag," or the retention of magnetism, after the circuit is broken. A long, steel rod called the "chronometer" is suspended from the high magnet and a short one called the "registrar" from the low magnet. Both rods have soft iron tips that demagnetize quickly. A copper or zinc tube is slipped over the chronometer rod and extends nearly the length of the rod. This tube is called the "recorder" and, when in place, the weights of the two rods are the same, or about one pound each.

On the base is a knife actuated by a spring and so located that the chronometer, in falling, passes close to its edge when the knife is cocked. The knife is held in the cocked position by a flat, plate-like trigger which extends under the registrar.

The current is usually supplied by storage batteries and passes through rheostats and ammeters connected in the circuits of each of the electro-magnets. By means of the rheostats and ammeters, the strength of the current and consequently of the magnetic fields can be equalized in both magnets, so that each will lose its magnetism at the same speed when the circuit is broken.

While the circuits through the two magnets are independent of one another, they both pass through the disjunctor, whereby both circuits may be broken at the same instant. The independent circuit of the magnet supporting the chronometer rod passes through a fine wire, called the muzzle wire, stretched across the path of the bullet and located close to the muzzle of the gun. The circuit for the registrar magnet is completed through a circuit interrupter placed at some distance from the muzzle of the gun. For measuring the velocities of small arms bullets, this interrupter usually takes the form of a piece of armor plate with a hardened surface that will not be deformed by the repeated impact of bullets, having a delicate adjustable spring contact on its back. The adjustment of this spring contact is so delicate that any jar of the plate will cause the circuit to break. The spring causes it to remake contact immediately, which eliminates any need of manual operation and saves time. In measuring the velocities of artillery projectiles, two wire screens are used, the projectiles breaking the wires as they pass through. Such screens must be repaired or replaced after each shot and in small arms work are not often used except for armor piercing bullets.



The Boulenge chronograph "hook-up" before the shot has been fired.

After the chronograph is adjusted and before doing any firing, the chronograph and registrar rods are "hung up" on their respective magnets and both circuits are broken at the same instant by means of the disjunctor, so that both rods will fall at the same time. When the registrar strikes the trigger, the knife is released and flies out, making a cut or nick on the recorder or tube carried by the chronometer rod at the point which is opposite the knife at that instant. The distance that the chronometer drops before the knife strikes it represents the free fall and will be constant from one shot to another. The mark made on the recorder is the zero mark, or disjunctor point, from which subsequent measurements are taken.

The rods are then hung up again and a shot fired. The instant the bullet breaks the muzzle wire, the circuit in the chronometer magnet is broken and the chronometer rod begins to fall; and when the bullet strikes the terminal target, breaking the circuit in the registrar magnet, then the registrar falls. Both rods continue to drop together but when the registrar strikes the trigger, the knife flies out and cuts a nick in the recorder at the point opposite the knife edge at that instant. The distance between the zero mark and the one made by firing represents the time required for the bullet to pass from the muzzle wire to the terminal target and as this distance is definitely known, it is a simple matter to calculate the time of flight and the velocity in feet per second. As a matter of fact, such calculation is not necessary as the scale with which the distance between the marks is measured is graduated to read directly in feet per second, thus saving a lot of time and trouble.

In taking rifle velocities, the muzzle wire is located three feet in front of the muzzle to avoid its being broken by the muzzle blast. The terminal target is located 150 feet from the muzzle wire and this distance, plus the distance from the muzzle of the rifle to the

muzzle wire makes a total of 153 feet that the bullet travels, although the velocity is measured only over 150 feet. In this case the velocity obtained is the average over the 150 feet between muzzle wire and terminal target, and is the velocity at the midpoint of this distance, or at 78 feet from the muzzle. Sometimes the terminal target is placed 100 feet in front of the muzzle wire, giving a velocity at 53 feet from the muzzle; or any other convenient distance may be used.

For pistol or artillery velocities, the distances are smaller and greater respectively and each measuring scale is stamped with the distance between "screens" that it is suited for.

Velocities taken as described are the average velocities over the distance and are called "instrumental velocity." As a bullet begins to slow up once it is beyond the influence of the muzzle blast, it is not traveling as fast when it strikes the target as when it left the muzzle of the arm it was fired from. It is a difficult matter to find the exact velocity of a bullet at the instant it leaves the muzzle of a rifle, but it can be found approximately as follows:—Mark one horizontal edge of a sheet of cross section paper off in units of feet, starting with zero at the right to represent the muzzle of the gun and continuing to the left, say, in increments of ten feet each, running up to at least eighty feet. The right hand vertical side of the sheet should be marked off in units of velocity. Fire a series of shots at 78 feet in the usual manner and plot the result as one point of a velocity-distance curve. Then move the terminal target up to about 38 feet from the muzzle, fire another series of shots and plot a second point on the cross section paper. Now, connect the two points and extend the line to the right until it reaches the zero, or muzzle point, and you will have the approximate muzzle velocity. A more accurate result can be obtained by firing the series at a greater number of different distances but two points will prove fairly accurate; at least much more accurate than guessing.

A Boulenge chronograph, in good condition and carefully adjusted, can measure such short intervals of time as that between the time the trigger is pulled and the time the bullet leaves the muzzle of the barrel. Such a fine adjustment is hardly necessary for routine testing of ammunition, but is a virtue in testing powder lots. The powder companies will take the velocities of hand loaded ammunition for any handloader of an experimental turn of mind, at a very reasonable charge.

The Aberdeen chronograph is also used to a limited extent for measuring bullet velocities. This apparatus takes the form of a synchronous motor, mounted with the shaft in a vertical position. To the shaft is assembled a shallow pan or metal dish with straight sides, carefully turned and balanced. This pan carries a strip of thin paper equal in length to the inside circumference of the pan. Instead of two weights, two points are located, one just over the other and close to the pan wall. These points are connected to separate electrical circuits, one passing through the muzzle wire and the other through the disjunctor. The bullet, on breaking the muzzle wire, causes a spark to jump from its point to the wall of the pan, burning a tiny hole in the paper and when the bullet strikes the disjunctor, a second spark jumps through the paper. The distance between the two holes is an indication of the instrumental velocity. It can be seen that the accuracy is dependent upon the pan rotating at a proper and uniform speed and if it does this, the paper can be (and is) marked off with lines so that a direct velocity reading may be taken from it.

A synchronous motor is one especially wound to maintain a uniform number of revolutions per minute, regardless of fluctuations in the line voltage. Actually, it does not do this but will lose or gain more or less speed as additional load is taken off or put on to the line the motor is running on. What it does is to adjust itself to these changes and return to its normal speed. These temporary fluctuations in speed are of no consequence for all ordinary purposes, but they are fatal to the taking of accurate velocities. An Aberdeen chronograph would be of little use if hooked up on a city line, especially a power line. If the lady next door turned on her electric stove just as a shot was fired, the reading of velocity given by the instrument would be worthless. These chronographs are at their best when operated by a separate generator of their own and on a line which is not used for any other purpose. Under such a condition, very accurate results can be obtained with them.

Preparation of Tables of Loads.

In working out their tables of charges, the powder companies use new, primed cases purchased from the commercial ammunition companies or, in the case of the Cal. ·30-06 cartridge, from Frankford Arsenal. These cases are primed with the primers that the manufacturer uses in loading his own ammunition and most of these primers are different from those sold for reloading purposes. The flash holes in the cases are made of a correct size for the primers used, but the use of a primer of different make from the cartridge case can give a very different order of ignition to the powder charge. All cartridge cases of the same caliber are not of the same capacity; some have thicker side walls and thicker heads than others. As the *outside* dimensions must be the same, within very close limits, any variation in the thickness of the metal in the cases will mean a variation in their internal volume. If two cases of different thicknesses are loaded with the same charge of powder, one will have a higher density of loading than the other and will consequently develop a higher pressure. Between the differences in cases and primers, it is a matter of chance if a hand-loader gets the same velocity and pressure from his reloaded ammunition that the powder manufacturer got, even though the handloader is meticulous in the preparation of his ammunition. The nearer the load is to the maximum r*ecommended* load for any cartridge, the more marked will be the effect of variations from the conditions under which the load was worked out. Any difference in bullet weight, diameter, shape, or hardness will also affect the ballistics.

In addition to variations in components, there are the guns to be considered. Chambers vary in size and shape and ammunition fired in an arm having a tighter chamber than the test gun will develop a higher pressure. The same is true if the bore and groove dimensions, and especially the throating of the barrel, are tighter or smaller.

Powder for testing purposes is kept in rooms or magazines, where the temperature is maintained at a uniform level, and tests for velocity and pressure are made with the powder at 70º F. Any increase in the temperature of the powder will cause it to ignite more easily and to burn more rapidly, thereby causing a rise in the chamber pressure above the expected point. Exposing ammunition to the hot sun long enough to heat up the powder charges will usually produce some surprising results and doing this with some cartridges has been known to increase the pressures over 10,000 pounds per square inch. Maximum charges, which are much in the nature of "proof charges" to begin with, will certainly become more dangerous if warmed up before firing.

The powder boys know these things and state very clearly in their folders and booklets of tables of charges that the figures shown are those obtained with the arms and components that *they* used. They further recommend that charges below the maximum *recommended* charges be used for the best accuracy and that in rifles with tight chambers the heaviest charges should be reduced several grains in weight. This is excellent advice to follow.

The tables of charges published by the powder companies give either the seating depth of the bullets or the over-all length of the cartridge for each load listed. This is done to show the condition under which the ballistics were developed. In the moderate and reduced loads, the exact seating depth of bullets is not of great importance, but it becomes of increasing importance as the charges approach the higher levels. With the heaviest charges shown in these tables, the bullets should never be seated deeper than the dimensions given in the tables. With full charges in such cartridges as the ·220 Swift, ·257 Roberts, or any others in which the cartridge is a close fit in the chamber, especially at the neck, even a few thousandths of an inch increase in the seating depth of the bullets will cause an appreciable increase in the chamber pressures.

If the reader believes from the foregoing remarks that the writer is a timid soul or an alarmist, he is mistaken. Variations in components such as primers, flash holes, volume of cartridge cases, etc, are matters a handloader seldom thinks of. To the average person, all cases of the same caliber are alike and a primer is a primer; just a little dingus that makes the cartridge explode. There is a lot more to them than that and while their variations can cause lower pressures, as well as higher ones, than are indicated in tables of recommended charges, their effect in a minus direction has been skipped over because it doesn't involve the matter of safety. Even when these variations operate to increase pressures they are not likely to result in dangerous pressures if the handloader observes carefully *all* of the information given in the tables.

In manufacturing arms and ammunition there must be manufacturing tolerances and all arms and ammunition of the same caliber are not exactly alike nor are the components that go into the manufacture of the ammunition alike. Bullets will vary a little in diameter and weight, and primers, however good they may be, will not be absolutely uniform from one lot to another.

In the establishment of pressure limits for different arms, experience has dictated a limit for each caliber, make or type that should not be exceeded. This maximum pressure limit is not necessarily close to the bursting point of the gun. As a matter of fact, no one knows what the bursting point of a gun is. One arm may stand a prodigious charge of powder, while another of the same make, model and caliber lets go with what appears to be a perfectly normal charge. Maximum pressure limits are established, however, to allow a reasonable margin of safety, to take care of the unavoidable variations in ammunition and ammunition components. One primer out of ten thousand or more may give an exceptionally hot flash and over-ignite the powder charge, A cartridge case may have a hidden flaw that cannot be seen by the inspectors, or an over-size bullet may get into a cartridge, to say nothing of errors in powder charges. The margin of safety is left to protect the shooter who may happen to shoot a faulty cartridge once in a while and in loading ammunition the handloader should guard against any encroachment on this margin of safety; it is the most important part of a firearm. All is not gold that glitters and all ammunition components are not alike just because they look alike. To load ammunition intelligently, especially the heavier loads, one must know what he is dealing with.

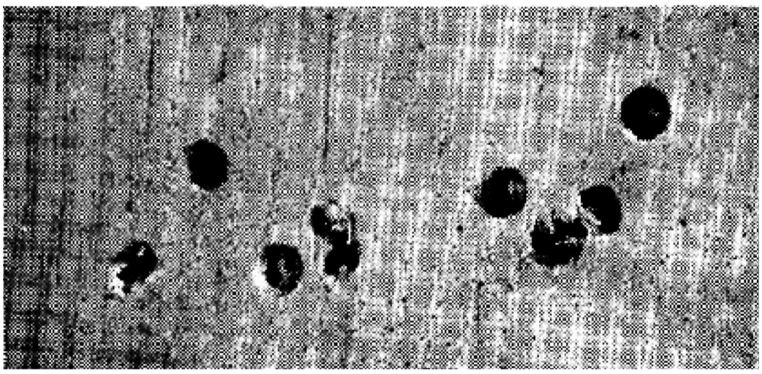
Maximum Loads.

Maximum loads are those that exceed the limits of pressures prescribed by experience and intelligent ballistic determinations. They are over-loads and are therefore dangerous. Sometime, someone lit on the not particularly bright idea that some arms are stronger than others using the same caliber of cartridge and that the ammunition manufacturers load their ammunition to be safe in the weakest arm of each caliber. It is true that some arms are mechanically stronger than others but regardless of the arm, it is the cartridge case which has to hold the gasses in. The idea that the ammunition manufacturers load for the weakest arm of each caliber is pure fiction. There are plenty of imported arms in use which have such narrow margins of safety that they ought not be fired with normal loads. Just as one example, do you believe that any cartridge manufacturer loads his ammunition to be safe in the pot metal Spanish guns with which the American market was flooded shortly after the War? Of course not! And plenty of this junk has popped open like a jack-in-the-box with perfectly normal ammunition. Ammunition is loaded by the factories to the highest level of pressure that will be reasonably safe under the varying conditions of use it is likely to be subjected to, IN GOOD ARMS THAT ARE IN GOOD CONDITION. The effect of the improvements that have been made in alloy steels and the additional strength of arms resulting from their use has been to increase the margin or factor of safety and to decrease the number of accidents that occurred with older arms. In spite of this increased strength, accidents will occasionally occur with factory loaded ammunition.

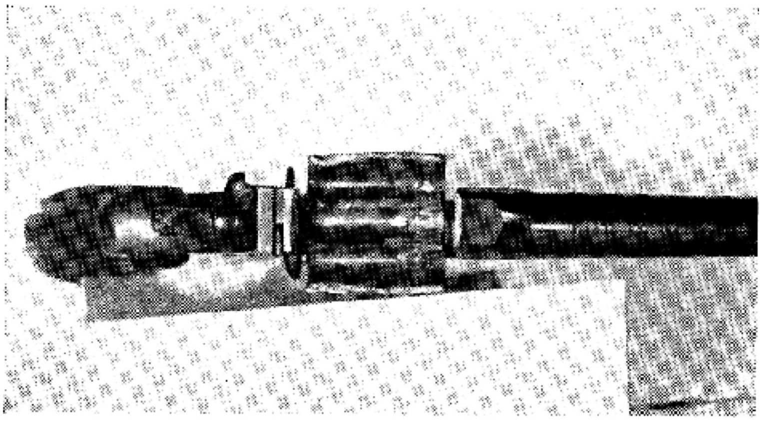
Before we get too far away from the subject, let's take a look at the ·30-06 cartridge. This cartridge was developed as the standard military cartridge for the armed forces of the United States. It was especially made to be used in the Model 1903 Springfield rifle and that rifle is one of the strongest there is. Every rifle taking the ·30-06 cartridge that has been brought out since the Springfield made its debut *has been built to hold the cartridge.* The cartridge has *not* been loaded to suit these rifles. This is true of many other calibers as well. The Springfield rifle has been loaded with prodigious loads of many kinds of powder and has withstood them in laboratory tests, yet these rifles occasionally blow up in service with apparently normal loads—and so do all other rifles.

Now, it is well for the reader to bear in mind that there is a big difference between a wrecked and a blown up rifle, or any other type of firearm. A wrecked rifle is one that is destroyed by *any* cause when fired. A blown up rifle is one that is wrecked because of a mechanical or structural weakness in the arm itself. For example, a cartridge case may give way at the head and blow a firearm all to hell, but such a blow is the fault of the cartridge case or load and not due to weakness in the arm. If the shoulders supporting a breech block shear off or a firing pin blows out with a normal load, that is the fault of the arm. The difference is a technical one and of little interest to the shooter who has his puss parked alongside of the action when it lets go, but when you hear of any rifle not blowing up under excessive pressure don't try to duplicate the load used with the belief that the rifle used in making the test remained intact. Even if it did there would be no object in duplicating the experiment.

The Model '95 Winchester was chambered for the ·30-06 cartridge and while its action was not as durable as that of a bolt action rifle, it was safe with this cartridge, provided the action was in reasonably good condition. In a sense, the ‘95 would not stand what the Springfield would and some time someone got the crazy idea that when ammunition was reloaded for the Springfield, it could be loaded to much higher pressures than for the '95. No doubt this was on the erroneous theory that the factory cartridge was loaded for the '95, which was not quite as strong mechanically as the Springfield.



A crude test of primer performance. Two "groups" made by firing the primers from the inside of the cup. Note the deep penetration of the left hand group. This indicates violence but the primers in the right hand group were, by far, the best igniters of the two.



A revolver blown up by the effects of three overloaded cartridges. Note that the set-back from the fired cartridge also exploded the two lying on both sides the top one.

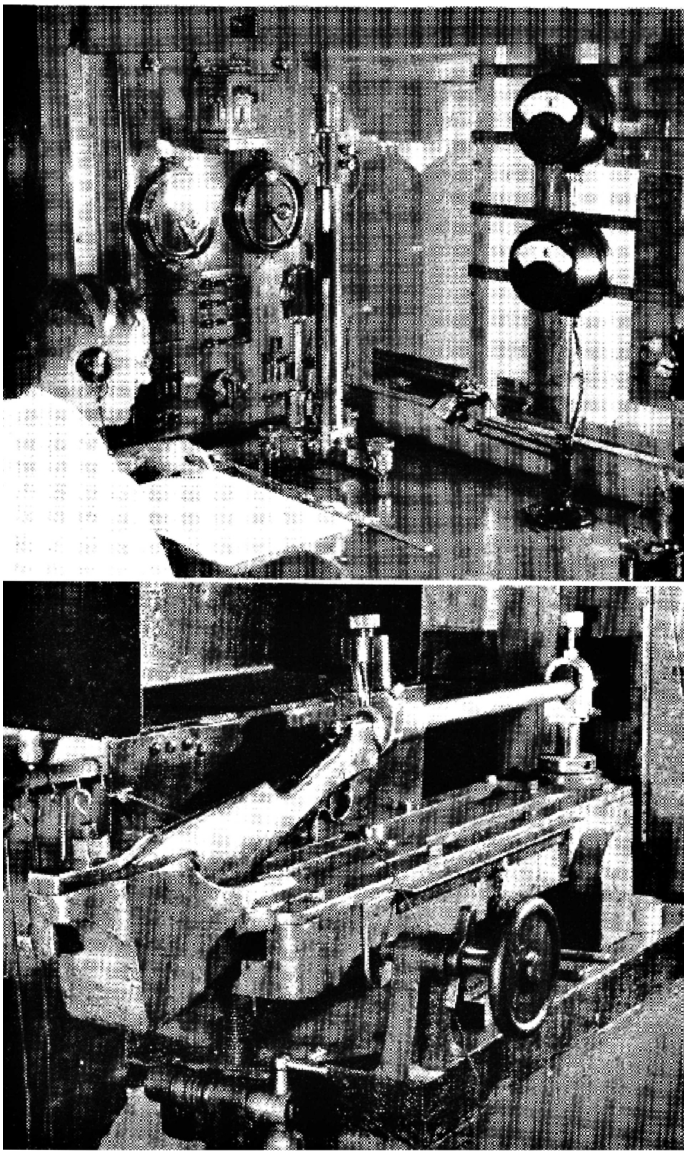
If the reader will just stop and think for a moment he will realize that the ammunition business is a highly competitive one. Each manufacturer is constantly trying to get the jump on the other with some new bullet, load or cartridge and, whether it be for better or for worse, one of the things which most quickly causes the shooting public to quit one brand of ammunition and turn to another, is velocity. The minute a manufacturer announces a load that will develop a few foot seconds higher velocity than that of his competitors, the boys flock to his banner.

But, are experience and judgment thrown to the four winds just to get a little more velocity? They are not! The ammunition makers know that to exceed the prescribed limits of pressure for any cartridge will result in a flock of nice fat damage suits from those using the ammunition because of injuries received from its use.

Now let us look at the tables of powder charges published by the powder companies. These companies depend for their livelihood on the sale of powder and the more powder they sell, the better their business is. They would be tickled to pieces to tell you to stuff your cartridge cases full of powder, in order to increase the consumption if it were safe to do so. They prepare their tables with exacting care, using the best of laboratory testing equipment and personnel that have had years of experience. The heaviest loads in any of these tables *are the heaviest loads that should be used under any circumstances* and they are not for the novice at reloading to monkey with.

In developing any new factory cartridge, the ammunition and powder companies work very closely together to develop a suitable powder. When the desired velocity has been obtained with apparently safe pressures, a small lot of the ammunition is loaded and sent to different parts of the world so that it may receive a practical test under different climatic conditions. Sometimes it is placed in storage at different points and later re-tested for possible ballistic changes. When it appears that the product is satisfactory, a run is made and sent out to the trade, a careful record being kept of the dealers or sections of the country that it goes to. This lot will carry a distinctive code number. If complaints come in from shooters, the manufacturer always wants to know the code number on the box the cartridges were taken from and if the complaints are numerous or serious, that lot of ammunition is withdrawn from the market and the source of trouble eliminated before any more is sent out.

That is just a brief example of the care that must go into the manufacture of ammunition if it is to be safe under average conditions and this general procedure is necessary because of the high levels of pressure to which factory ammunition is loaded. In spite of all the testing facilities and the care taken during manufacture, plenty of lots of ammunition have had to be recalled and salvaged. New loads have been worked out, and even new cartridges, and after tests and trials they are put on the market. The catalogues and ballistic tables are published and tons of cartridge boxes printed showing the velocity developed by the ammunition that is to go in them and then trouble develops. That ammunition has to be called back and salvaged. The powder has to be changed and the load reduced, with a resultant loss in muzzle velocity, but the advertising is out and there is no use crying about it. There are and have been many cartridges that don't develop the advertised velocities, just for this reason and not because of intentional deception on the part of the manufacturers. And what difference does it make? None at all. The ammunition is accurate, it shoots flat and it kills game nicely and if it does that what difference does a hundred foot seconds or so mean?



Apparatus for the taking of pressures and velocities.
Upper view shows chronograph room of the Hercules Powder Company's ballistic station at Kenvil, N. J. Chronograph is set for the taking of time interval as soon as the shot is fired. Lower view shows firing point with rifle set in the rest for taking of both velocity and pressure. Rifle is special pressure gun with yoke mounted over the chamber for the taking of pressures by radial system.

PLATE XII.

If these things happen when all the facilities of an ammunition factory and two or three ballistic laboratories are used, where does the handloader get off when he starts monkeying with maximum loads? As a matter of fact, he usually gets away with it, which bears out the old adage that “the Lord looks out for fools and little children.”

There is usually at least one barn-yard ballistician in each shooting community who delights in overloading his ammunition. You can always tell when one of them is around, for his first act on arrival at the range is to tell everyone who will listen to him how much powder he is using. After he feels that the assembled multitude is duly impressed, he steps up to the firing point and touches off something with a muzzle blast that would make Gabriel's trumpet sound like the peep of a canary with tonsillitis. And the bullet, upon reaching the paper target some two hundred yards away, passes completely through it instead of bouncing off as any ordinary bullet might do! Then the mighty magician turns around with a triumphant air and awaits the applause, which is usually lacking.

Engaging this person in conversation will probably disclose the fact that what he knows about ammunition can be written on the back of a postage stamp and leave room for the Lord's Prayer besides. And the pity of it is, that it isn't his fault. He is probably only trying to duplicate a load he has read about in some magazine article that ought never to have been published. Time and time again, I receive letters very much as follows:—“I have just bought a rifle for the —— cartridge and want to reload my own ammunition. What tools do I need and what is the maximum load I can use in this cartridge?” Now there's a combination for you! A guy who doesn't even know enough about reloading to pick out a set of loading tools, wanting to load dangerous loads! I believe that the responsibility for this dangerous propaganda lies squarely with the gun editors, past and present, of our shooting magazines who, either because of their own limited experience or lack of thoughtfulness, recommend maximum loads or permit articles to be published that do recommend them.

When we have a kink in the gut we call a doctor and when we want our teeth fixed we go to a dentist and we don't argue or disagree with their findings, because we know that they know a lot more about their profession than we do. Yet, when we read of some heavy load of powder that hasn't happened to do any damage, there is a strong inclination to disregard the source from which the information comes, unreliable and irresponsible as it may be, and to figure that this great discovery is something that the powder boys

overlooked. The place to get authentic information about powders and loads is from the powder companies, and their folders or tables of charges have been prepared with no other purpose than to give it to you.

Having given maximum, or over-loads, about 1% of the condemnation they deserve, and without the use of profane language, permit me to say that this is not a condemnation of the use of any load or loads used in the process of intelligent experimentation. In the loading of ammunition as in all other things, there would be no progress if we were always to abide by the present accepted order of things. Some very important advances in the art of ammunition manufacture have had their origin in the experiments of handloaders with a yen to find out things for themselves and the education and intelligence to do the finding out in an orderly, reasoning manner. Such experiments are by no means limited to high pressure loads, but high pressures are likely to be encountered when experimenting with the unknown. However, the field of experimentation is not for the average handloader and especially not for him who hasn't the money to do it properly, for it is often an expensive game to play. The experimenter should realize that working with high pressure loads is a dangerous game and conduct himself accordingly, proceeding slowly and collaborating with those who are likely to be able to steer him away from pitfalls.

Therefore, anything I have said against maximum loads is not intended to apply to the experimenter but rather to the every-day reloader who is just reloading his ammunition for ordinary shooting purposes. Maximum loads will give very little more velocity than ordinary full loads, but much higher pressures. They are less accurate than normal loads and especially so over the ranges at which most reloaded ammunition is used, and there is no reason or excuse for their use.

The Use of Tables of Charges.

Tables of charges can be divided into two classes; those published by the powder companies and those found in handbooks on reloading. In preparing their tables of charges, the powder companies fire the ammunition for velocity and pressure only. They do not always fire it for accuracy, but because of the similarity of some of the loads to those used by the ammunition companies, plus an extensive experience, the loads published in their tables will be found to give good results. The heaviest charges given are merely to show the limit *that should not be exceeded* and will not necessarily give the best of accuracy.

The tables in handbooks are for the most part loads that have proven accurate in actual use and which have been checked with the powder companies for accuracy and safety. The loads taken from either of these sources can be relied upon for safety, if the loading conditions are duplicated.

In addition to these tables, there are the loads which are described in magazine articles. Most of these are good, but charges taken from such sources are the least reliable of the three.

Every reloader should have in his possession the tables of charges published by the powder companies for the powder or powders that he is using, and he should renew his file of these folders about once every year, for, as we have seen, different lots of the same kind of powder are apt to differ in characteristics and the powder companies make up new tables when a new lot of powder requires a change in the charges. One will sometimes find a discrepancy in the weights of charges in two or more different tables, all giving different weights of charges for the same cartridge, bullet, and velocity. This is because the results published are based on the use of different powder lots.

For the benefit of the inexperienced, it is not the best idea to get all the folders and tables from the powder companies, but only those relating to the powders suitable for the cartridge or cartridges which are to be reloaded. Naturally, the beginner at the handloading game does not know much, if anything, about the many different kinds of powder that there are and consequently doesn't know what to ask for. The information which should be given is as follows: The manufacturer's designation of the cartridge the powder is to be used in. This is essential and it is sufficient in the case of a pistol or revolver cartridge. But if one is reloading rifle ammunition, certain additional information should be given.

In this case, state whether you wish to reload with reduced or full charges and also indicate whether you are going to use plain base or gas-check cast bullets, jacketed bullets, or all three. This data will enable the source of information to send material which will be of real use to you, rather than just a handful of literature that may prove confusing and result in your selecting a powder other than the best one for your purpose.

Some powders, because of the high pressures under which they must be burned to perform properly, can only be used with jacketed bullets. Others having a wider tolerance may be used with both jacketed and plain base bullets, while still others suitable for gas-check bullets can also be used with plain base bullets as well. There are powders which should be used only with jacketed bullets in the smaller cartridges that are excellent for reduced loads using cast bullets in the larger cartridges. These powders are so numerous and overlap one another so that there is no use in attempting to lay down definite rules regarding them but if, in inquiring for powder folders containing tables of charges, you give the proper essential information as suggested above, you will give the fellow who gets your letter a chance to send you something that will be of real help.

If you are a beginner at the game, you will still be in something of a quandary as to which one to select. To make a proper selection isn't as difficult as might appear at first glance for, *the most efficient powder for any cartridge with any kind or weight of bullet is the one that will give the desired velocity with the lightest weighs of charge.* This does not refer particularly to a comparison between single and double base powders and the rule is applicable to either kind. Now, let's take a concrete example to see just how this rule works out.

I am just breaking in to the reloading game and am all pepped up about it. I have just received a nice, shiny Model 1917 rifle that cost me six and a half bucks, some 173 grain boat-tail bullets, and some F.A. No. 70 primers that I purchased through the Director of Civilian Marksmanship, also a set of reloading tools, I have some empty cartridge cases and I'm all-atwitter to get to shooting and show the boys how good I am, but I don't know just what powder to use. Of course I don't want any squib loads because them's only for kids, nor do I want any maximum loads, but I do want something with some soup behind it to make the boys sit up and take notice. S-o, I'll use the heaviest load that the powder tables give and be very careful about the way I load it. So far, so good.

I have a pretty red, white and blue book that I got from the duPont Co., so I sit down to apply the above rule, picking out the heaviest loads permissible for use with the 173 grain boat-tail bullet and this is what I get:

I.M.R. 4198	39·5 Grs.	2615 f.s.

I.M.R, 3031	48·5 Grs.	2800 f.s.
I.M.R. 4320	51·0 Grs.	2860 f.s.
I.M.R. 4064	51·0 Grs.	2820 f.s.

It is quite clear that the choice for the kind of a load I am looking for, lies between No. 3031 and No. 4320 powders. I.M.R. No. 4320 will give me the higher velocity of the two but it requires 2·5 grains more than No. 3031 to give me only 60 f.s. more velocity and 60 f.s. isn't a whole lot more than the normal fluctuation in velocity that is permissible from one cartridge to another, furthermore, that much difference doesn't amount to a hill of beans at such a high velocity. So No. 3031 is the most efficient of the two and that is the powder I buy.

The ammunition loaded, I repair to the range and blast away at the two hundred yard target, and with very good results. I am elated! New gun, swell ammunition 'n'everything, when along comes a guy. (To avoid a fight or an argument, "the guy" will be me also.) I roll over on my side and remark, "Got a new gun. How'm I doing?"

"You're doing alright but what in hell have you got in that ammunition?"

"Why! 48·5 grains of 3031; ain't that alright?"

"Sure", says the guy, "but it's going to wear all the hair off your belly; it's shoving you back about six inches every time you shoot. If you load that bullet down to about 2200 foot seconds, you'll get better accuracy at this distance and save yourself some money to boot."

Ain't that something! Here I was, sitting on top of the world, and this guy has to send the enthusiasm in my thermometer down about thirty degrees, but my shoulder *is* commencing to feel it and for some reason or other my lip is swelling up, so when I get home I take another look at the red, white and blue book to see what load will give me 2200 f.s. velocity.

Powders Nos. 4064, 4320 and 3031 don't show any charges giving velocities as low as 2200 f.s, and I don't know whether or not I will get complete combustion and uniform burning if I go below the limits shown, but No. 4198 shows a charge of 25·0 grains giving a muzzle velocity of 1830 f.s. and another of 39·5 grains giving 2615 f.s. As these loads in the ·30-06 cartridge, with the 173 grain boat-tail bullet, approximately represent the tolerance of the powder, the velocity curve will, no doubt, show an orderly and fairly uniform progression in velocity for each grain increase in the powder charge between these limits. I can plot these points on cross-section paper as already described, and pick out my load but I haven't any cross-section paper, so I interpolate in the following manner, figuring to the nearest tenth of a grain weight of charge and to the nearest foot-second:

	39·5 Grs. gives	2615 f.s.
	25·0 Grs. gives	1830 f.s.
The difference is	14·5 Grs.	785 f.s.

Dividing 14·5 into 785 gives the change in velocity for a change of one grain in the weight of the powder charge or, in this instance, 54 f.s.

I want a load that will give 2200 f.s. 25·0 grains of powder gives 1830 f.s, and deducting this from the desired velocity gives a difference of 370 f.s.

As 54 f.s. equals the change in velocity for one grain of powder, dividing 54 into 370 will give the increase over the 1830 f.s. load to bring the velocity up to 2200 f.s. This figures out 6·8 grains which, when added to the 25·0 grains necessary to develop 1830 f.s., gives 31·8 grains. Therefore, a load of 31·8 grains will give me 2200 f.s. muzzle velocity.

This simple method, while not always giving precisely accurate results, will give a very close approximation. All that is necessary is to have two charges of the same kind of powder for the same cartridge and bullet. Nothing must differ except the weights of the charges. In explaining it, the object has not been to teach common arithmetic, nor to insult the reader's intelligence, but to show that the efficiency and suitability of a powder does not depend upon the caliber of the cartridge and the kind and weight of bullet alone, but on the desired velocity as well.

Charges for Gas-check Bullets. Some powder tables do not give charges for gas-check bullets but not infrequently the powder that the table pertains to can be used with such bullets and with entire success. Of course, where loads are given for gas-check bullets, the same rule given above can be applied in selecting the most efficient powder, not overlooking the desired velocity in applying it. But gas-check loads can also be picked from some tables of loads for jacketed bullets. For this purpose, velocity figures are much more useful than those for pressures, because the performance of gas-check bullets depends much more on the velocity at which they are driven than upon the pressures developed behind them. While no definite rule can be given as to the velocities at which gas-check bullets may be driven, 1800 f.s. is a reasonable and conservative limit. Actually, some of them can be driven at well over 2000 f.s. with good accuracy; it all depends upon the caliber and weight of bullet, the alloy from which it is cast, the amount and kind of lubrication it carries and the arm in which it is fired. Some gas-check bullets will shoot with extreme accuracy in a 30 inch barrel if driven at moderate velocities yet, if they are speeded up, they cause leading near the muzzle and become very inaccurate. The same bullet can be fired at a much higher velocity in a 24 inch barrel because, in spite of the additional friction and heat from the increased charge, the lubrication is not exhausted before the bullet leaves the muzzle of the shorter barrel.

To pick a load for a gas-check bullet from a table of charges for jacketed bullets, select a load for a jacketed bullet of approximately the same weight as the gas-check bullet, that gives a muzzle velocity of about 1800 f.s. If the velocity shown is a little higher than this, it doesn't matter and the load may still prove to be a very good one. After all, the only way to find out whether any load is accurate or not is to fire it.

There is one thing to bear in mind in selecting loads in this way. Any cast bullet, however hard the alloy may be from which it is cast, is soft in comparison with a jacketed bullet. It requires less force and less time for the powder gasses to impress it into the rifling of the barrel, which means that the lead alloy bullet will accelerate faster than a jacketed bullet of the same weight. Because of the lesser resistance and quicker forward movement of the alloy bullet, the chamber pressure will not be quite as high as with a jacketed bullet and because of the more rapid acceleration of the soft bullet, its muzzle velocity will be higher. In other words, all other things

being equal, a gas-check bullet will develop a lower chamber pressure and a higher muzzle velocity than a jacketed bullet. The rule is not inflexible but the exceptions to it are few and far between. A comparison cannot be made between a gas-check bullet and a boat-tail bullet because the latter has a short bearing surface for its weight, but the rule holds up well in comparisons with flat base jacketed bullets. For example, I have a table of charges in front of me now and find these comparative Velocities for a certain cartridge:

150 grain jacketed.	16·0 grains	1320 f.s.
154 grain lead.	16·0 grains	1460 f.s.

In spite of the slightly heavier lead bullet, the same powder charge gives it 140 f.s. more velocity than the jacketed bullet.

At the higher velocities, where the chamber pressure builds up quicker, the difference between the velocities of the two different types of bullets is less marked and occasionally, charge for charge, the jacketed bullet will have slightly the higher velocity of the two. This may very possibly be due to the severe upsettage of the softer bullet but, at any rate, when this condition does occur, it is at velocities above which gas-check bullets can be expected to shoot accurately.

Naturally, some powders are much better adapted for use with gas-check bullets than others and those powders should be used wherever possible. The only object in suggesting a means of selecting less desirable powders, such as those intended for jacketed bullets primarily, is because we often have to make the best use of what we have, regardless of whether there is something better elsewhere.

Loads for plain base cast bullets can be picked from tables of charges for powders not particularly recommended for such bullets, by the means described above, but the velocity limit for plain base bullets can, for this purpose, be placed at 1600 f.s.

Powders that do not meet the limits of velocity suggested for cast bullets can sometimes be used with pretty good results, but this is getting pretty far from the path of righteousness. To use any of the military powders with plain base cast bullets is almost foolhardy, in a land where powders are as easily obtainable as here in the U. S. Always use the correct powder for your purpose, if you can possibly get it.

Incomplete Combustion. As has been previously pointed out, each kind and type of powder has a range of pressures over which it burns uniformly, this range being known as the tolerance. Past the upper end of the tolerance of a powder, erratic and dangerous pressures may occur but there is no danger at all connected with loading them below the lower limit. The evil in this direction is poor burning and incomplete combustion. The line of demarcation at the ends of the tolerance is less sharp at the lower end than at the upper; it tapers or shades off into an unsatisfactory condition. Therefore, loading to a little lower velocity than is indicated in the powder tables may give very good results. The charges may not burn completely but if the burning is uniform from one cartridge to another, the accuracy will still be good. But in using charges that are likely to develop velocities appreciably below the lowest levels shown in the tables, the reloader should watch his barrel carefully and clean it well after firing, regardless of the type of primer used.

The products of combustion of all smokeless powders when burned completely are nitrogen, hydrogen, carbon dioxide, carbon monoxide and water, the latter in the form of vapor. When the combustion is not complete, that is, when smokeless powder is burned at pressures below normal, a residue is sometimes left that will cause rapid oxidation of the barrel steel. I have, by burning powder at a pressure about 10,000 pounds below its tolerance, produced streaks and roughness in the throat of a barrel by firing as few as fifty rounds. The condition appeared much worse when the barrel was viewed from the breech in the ordinary manner, than after it was sawed in two, I was able to produce approximately the same effect on the barrel by the application of a diluted solution of nitric acid, so believed that the original condition resulted from the products of incomplete combustion combining with atmospheric moisture to form traces of a dilute acid, but this theory has been disputed by authorities who know more about it than I do. It is not the purpose here to enter into a discussion of the physics or chemistry, but rather to point out the possibility of injury to a barrel from using high pressure powders in too greatly reduced charges.

Notes on the Selection of Powders.

Black sporting powder comes in three different granulations and the uses of the different granulations can be roughly classified as follows:

FFFg. This is the finest granulation of the three. It is suitable for use in revolver cartridges not exceeding caliber ·38, having cartridge cases not more than ¾ inch long. It is also suitable for use in small rifle cartridges such as the ·22 W.C.F., and other Cal. ·22 center fire cartridges now obsolete, as well as in muzzle loading rifles up to Cal. ·38.

FFg. This is the medium granulation and has the widest use. It is suitable for practically all rifle and revolver cartridges up to and including the ·45 calibers, except for the small ones already mentioned. This granulation is also good in muzzle loading rifles of from Cal. ·38 to ·45.

Fg. This is the coarsest granulation of black powder. It should be used in all cartridges of a caliber above ·45 except the ·50 Remington Pistol cartridge for which FFg is better, and in all muzzle loading arms larger than Cal. ·45. It is especially recommended for old muzzle loading military muskets and is similar to what used to be known as "musket powder."

Kings Semi-Smokeless Powder. This powder is manufactured in a greater variety of granulations than black powder and no rule of thumb can be laid down as to the grain size that should be used for different cartridges. To list the calibers and appropriate granulation to use for each one would merely mean copying the table of charges published by the manufacturer. As this table can be had for the asking, there is no object in taking up space with its publication here.

Smokeless Powder For All Pistol and Revolver Cartridges. duPont pistol powders Nos. 5 and 6, and Hercules Bullseye are the powders best adapted for these cartridges for loads developing normal velocities or for reduced or mid-range loads. For so-called high velocity loads in revolvers, Hercules Unique will give the highest velocities with normal pressures. Unique, while essentially a powder for rifle cartridges of small capacity, has proven to be an excellent one for developing more than normal velocities in revolvers, but it is not recommended for normal or reduced loads in revolvers or pistols. duPont No. 80 can also be used in revolvers,

although it is a rifle powder. If used in revolver cartridges it is, like Unique, at its best when used in the heavier charges, as the combustion is poor at low pressures.

Therefore, he who wishes to reload revolver or pistol cartridges should obtain the powder folders covering those powders mentioned above and he will then have “the works.” With them as a guide he can pick heavy or light loads and, so to speak, romp around to his heart's content within the prescribed limits of charges.

Smokeless Rifle Powders. Smokeless powders for rifles cannot be described or disposed of with the same facility as the pistol powders. There are so many rifle powders, their latitude is so wide and they overlap one another to such an extent that any ordinary description would be involved and inadequate. The following table is offered as an aid to requesting the proper powder *folders* or tables of charges for any or all of the most popular rifle cartridges in use at the present time. It does not include freak or special cartridges that are the handiwork of private experimenters, however virtuous they may be. Incidentally, whatever charm these cartridges possess in the way of extreme accuracy can be traced directly to the close relation of cartridge to chamber and throat, rather than to any black magic. This remark is in no way intended to reflect upon the private experimenter or any brain child that he may give birth to, because this type of individual, with his inquiring turn of mind, has contributed much to ammunition development. But this table is one of powder folders and it would serve no purpose to include cartridges for which there are no charges in the folders.

There are a few other points about this table that should be pointed out in order to avoid misunderstanding. The table shows some powders as being suitable for use with gas-check and plain base bullets, in spite of the fact that they do not contain specific loads for such bullets. An examination of these tables will show the reason for this by comparing the velocities of some of the jacketed bullet loads with the velocities permissible with cast bullets.

duPont No. 80 and Hercules Unique approximately parallel one another in their range of usefulness, in spite of their entirely different natures.

The paucity of loads for the duPont I.M.R. Powders is due to the omission of any cast bullet loads from the duPont tables and such loads have only been indicated where the information in the tables make it possible to do so. For example, I.M.R. Powder No. 4227 is similar in its application to Hercules No. 2400, but there is nothing in the tables to indicate such a wide usage.

On the other hand, the multiplicity of loads for the Hercules powders is not alone due to the wide tolerances of double base powders, but to the fact that loads of the types indicated are given in the Hercules tables.

It is obvious, or should be, that where any powder is indicated as being satisfactory for jacketed, gas-check and plain base bullets, that this powder cannot have the same degree of efficiency for all of these bullets but directions have already been given for finding out the most efficient powder for any type or weight of bullet.

For the sake of uniformity, tables have been indicated for the three types of bullets mentioned in spite of the fact that no gas-check bullets exist in a few of the calibers given.

In requesting powder folders, it is always well to state the caliber of cartridge or cartridges that you wish to reload, as complete tables of charges are available in individual form for some of the more popular cartridges. And besides, the powder boys are not sitting around in rocking chairs all day but are constantly getting out new “dope.” What may be published today as the last word may not be correct tomorrow.

The tables only refer to those powders that are being currently manufactured and sold for reloading purposes by the powder companies. These are the best powders to use and are the ones that the reloader should endeavor to obtain. There are, however, other obsolete powders that can be used with entire satisfaction and as stocks of some of these powders are in the hands of dealers and more easily obtainable than some of the newer ones, the following comments are given on the more important ones as a guide to requesting tables of charges, where they are available.

duPont I.M.R. No. 1204. This powder has the same general applications as I.M.R. No. 4227 but is much less efficient and is useful principally with jacketed bullets because of its narrower tolerance. It can be used with cast bullets, in reduced loads, in some of the larger rifle cartridges, but the tables of charges for it do not contain any such loads. No more of this powder will be manufactured nor sent out by the manufacturer for reloading purposes.

	duPont Powders						Hercules Powders					
	I.M.R.4227	I.M.R.4198	I.M.R. 3031	I.M.R.4320	I.M.R. 4064	80	Unique	Sharpshooter	Lightning	HiVel No. 2	HiVel No. 3	2400
·22 Hornet, Jacketed	X					X	X					X
Gas Check						X	X					X
Plain Base						X						
·22 HI Power Jacketed		X	X	X			X	X	X	X	X	X
Gas Check		X				X	X	X	X		X	X
Plain Base						X	X					
·220 Swift			X	X	X							
Gas Check						X						
Plain Base						X						
·25 Rem.		X	X					X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X					
·257 Bern. Roberts		X	X	X	X					X	X	
Gas Check						X	X					X
Plain Base						X	X					
·250-3000		X	X	X	X			X	X	X	X	
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X					X
·25-20 Single Shot	X					X	X	X				X
Gas check	X					X	X	X				X
Plain Base	X					X	X					X
·25-20 Repeater	X					X	X	X				X
Gas Check	X					X	X	X				X
Plain Base	X					X	X					X
·25-35 W.C.F.	X	X	X	X				X	X	X	X	X
Gas Check								X	X	X	X	X
Plain Base						X	X					
·25-36 Marlin	X	X	X					X	X	X	X	X
Gas Check	X					X	X	X	X	X	X	X
Plain Base						X	X					X
·270 W.C.F.			X	X	X			X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
·30 Remington		X	X					X	X	X	X	X
Gas Check		X	X			X	X	X	X	X	X	X
Plain Base						X	X	X	X		X	X
·30-30 (·30 W.C.F.)		X	X					X	X	X	X	X
Gas Check		X	X			X	X	X	X	X	X	X
Plain Base						X	X	X	X		X	X
·300 Savage		X	X					X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
·300 H. & H. Magnum				X	X							
Gas Check						X						
Plain Base						X						
·30-06		X	X	X	X			X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X		X		X	X
·30-40		X	X	X	X			X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X		X	X	X
·303 Savage		X	X					X	X	X	X	X
Gas Check		X	X			X	X	X	X	X	X	X
Plain Base		X				X	X	X		X	X	X
·303 British			X	X	X			X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X		X	X
·32 Remington		X	X					X	X	X	X	X
Gas Check		X				X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
·32 Win. Special		X	X	X				X	X	X	X	X
Gas Check		X	X	X		X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
·32 Win. Self Loading	X							X	X			X
Gas Check	X					X	X	X	X			X
Plain Base	X					X	X	X	X			X
·33-20 (·32 W.C.F.)	X					X	X	X	X			X
Gas Check	X					X	X	X	X			X
Plain Base	X					X	X	X	X			X
·32-40		X	X					X	X	X	X	X
Gas Check		X	X			X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
·33 Win		X	X	X	X			X	X	X	X	
Gas Check		X				X	X	X	X	X	X	
Plain Base						X	X	X	X	X	X	

	duPont Powders						Hercules Powders					
	I.M.R.4227	I.M.R.4198	I.M.R. 3031	I.M.R.4320	I.M.R. 4064	80	Unique	Sharpshooter	Lightning	HiVel No. 2	HiVel No. 3	2400
·343 Win		X	X	X	X							
Gas Check												
Plain Base												
·35 Rem.		X	X					X	X	X		X
Gas Check		X	X			X	X	X	X	X		X
Plain Base						X	X	X	X	X		X
·35 Win.		X	X	X	X			X	X	X	X	X
Gas Check		X				X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
·35 Whelen					X							
Gas Check												
Plain Base												
·35 Win. Self Loading	X							X	X			X
Gas Check	X					X	X	X	X			X
Plain Base	X					X	X	X	X			X
·351 Win. Self Loading	X							X	X			X
Gas Check	X					X	X	X	X			X
Plain Base	X					X	X	X	X			X
·357 Magnum					X							
Gas Check						X						
Plain Base						X						
·38-40 (·38 W.C.F.)	X							X	X			X
Gas Check	X					X	X	X	X			X
Plain Base						X	X	X	X			X
·38-55			X					X	X	X	X	
Gas Check			X			X	X	X	X	X	X	
Plain Base						X	X	X	X		X	
·401 Win. S. L.	X					X	X	X	X			X
Gas Check						X	X	X	X			X
Plain Base						X	X	X	X			X
·405 Win.			X	X			X	X		X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
·44-40 (·44 W.C.F.)	X					X	X	X	X			X
Gas Check	X					X	X	X	X			X
Plain Base						X	X	X	X			X
·45-70			X				X	X	X	X		
Gas Check			X			X	X	X	X	X		
Plain Base						X	X	X	X	X		
·45-90		X	X				X	X	X	X		
Gas Check						X	X	X	X	X		
Plain Base						X	X	X	X	X		
6 m/m Navy					X		X	X	X	X	X	
Gas Check						X	X	X	X	X	X	
Plain Base						X	X					
6·5 m/m Mannlicher			X		X					X		
Gas Check						X						
Plain Base						X						
7 m/m Mauser			X	X	X			X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X		X	X	X	
7·62 m/m Russian			X	X	X			X	X	X	X	
Gas Check						X	X	X	X	X	X	
Plain Base						X	X	X	X			
7·65 m/m Mauser			X	X	X			X	X	X		
Gas Check						X	X	X	X	X		
Plain Base						X	X					
8 m/m Mauser (7·9)		X	X	X	X				X	X	X	
Gas Check						X	X	X	X	X	X	
Plain Base						X	X	X	X			
9 m/m Mannlicher			X		X							
Gas Check						X						
Plain Base						X						

duPont I.M.R. No. 17½. This powder is comparable in its range of usefulness, to I.M.R. No. 3031 but, being an early nitro-cellulose powder, its tolerance is narrower than that of No. 3031. 17½ is difficult to ignite but is an excellent powder when ignited properly. It has been used with gas-check bullets with a fair degree of success but its normal burning pressure is too high for such bullets and its proper use is in full loads with jacketed bullets. The "½" means that metallic tin is incorporated in this powder.

duPont I.M.R. No. 15½ This is another "tin" powder, comparable to the new I.M.R. 4064 in its range of usefulness. It was brought out particularly for cartridges of small bore and large powder capacity such as the Newton and Magnum cartridges and is not as efficient as its newer counterpart in the military range of cartridges. Like 17½ it is hard to ignite but satisfactory if ignited properly and used in full charges with jacketed bullets, in the limited range of cartridges for which it was made. No more of this powder will be manufactured.

duPont I.M.R. No. 1147. This is another of the single base or straight nitro-cellulose powders. I.M.R. No. 1147 was made especially for the Cal. ·30-06 cartridge using the 173 grain boat-tail bullet and it was a good powder as far as long range accuracy was concerned. The well known and justly famous 1925 National Match ammunition was loaded with this powder and that statement would be a tribute to any powder. 1147 is a fine grained powder and flows nicely through mechanical powder measures but, paradoxical as it may seem, the use of this powder was abandoned by the government because it would not measure through the loading machines with sufficient accuracy. The specifications for the Government ammunition call for a definite muzzle velocity within an equally definite limit of pressure. I.M.R. No. 1147 would develop the muzzle velocity alright but the pressures were so close to the permissible limit that even the little variations in loading it mechanically were enough to put them over the line. When we are reloading ammunition and get evidence of high pressure, we correct it by reducing the powder charge a little. In other words, we change the specifications of the ammunition to suit the powder. But you can't do that with military ammunition; the specifications stay fixed and if a powder doesn't meet them, the powder is changed and that is what happened to this otherwise excellent powder.

No. 1147, in comparison with the new range of duPont powders, occupies the position of, and has about the same application as, I.M.R. Powder No. 4320. While No. 1147 is now obsolete, powder tables are available for it.

I.M.R. Powders numbers 1204, 17½, 15½ and 1147 are all progressive burning powders and as their manufacture has only recently been discontinued all available stocks should be fresh and in good condition. Tables of charges are available for all of them, and while those reloaders who have their charges all established and who have been getting good results with them will want, quite naturally, to stick with them as long as they are obtainable, the beginner is urged to use the newer I.M.R., or other powders in their place. The powders given in the foregoing table are easier to ignite, burn more uniformly and will give better all-around results for reloading purposes.

I.M.R. No. 1185. This is a powder made especially for the Government for loading the Cal. ·30 Model 1906 M1 cartridge with the 173 grain boat-tail bullet, for military usage. It is not obtainable commercially and can only be bought by members of the National Rifle Association, through the Director of Civilian Marksmanship. No more of it is being manufactured and no more will be obtainable when present stocks are exhausted. I.M.R. 1185 can, probably, be used in some other cartridges than the Cal. ·30-06 but no such loading data is available for it. It is not suitable for reduced loads and its use is best confined to the Cal. ·30-06 cartridge, using the 173 grain boat-tail service bullet with the proper weight of charge. Frankford Arsenal furnishes proper loading data for the ·30-06 M1 cartridge.

Pyro Cal. ·30 d. g. This was the first successful military powder developed for the Cal. ·30, Model 1906 cartridge, which used a 150 grain, flat base, jacketed bullet. It is a plain burning military smokeless powder and was for many years the only military rifle powder used by the United States. Its name indicates its composition, the "Pyro" standing for pyro-cellulose, which is a nitro-cotton of low nitrogen content—(12·6%). The "Cal. ·30″, indicates the caliber it was made for and the "d", that diphenylamine was used as a stabilizer. The "g" indicates that the powder contains graphite. This powder was also sold commercially for reloading purposes and could be used in a variety of cartridges. The commercial powders were known as duPont No. 20, and Hercules No. 308 powders. The Pyro Powders had a rather narrow tolerance and could not and should not be used for reduced loads, nor with cast bullets.

Pyro Cal. ·30 d.g., was used in loading all war-time ammunition in ·30-06 caliber up until the completion of the Government war contracts. Much of this powder was of poor quality because of hasty manufacture and the inability to get ingredients of the proper degree of purity and a lot of it, as well as ammunition loaded with it, has gone bad in storage. But it was by no means all bad and there is still some of it around that is in serviceable condition. Any of this powder that may have been purchased from the Director of Civilian Marksmanship within a reasonable period of time may be relied upon and can be loaded according to the data furnished by the shipping arsenal.

If the powder has been obtained from unknown sources or has been on hand for a considerable length of time, the reloader is advised to reduce his charges at least 5% from the standard, or better still, not to use the powder at all. This also applies to old canisters of duPont No. 20 and Hercules No. 308 powders. More or less of the volatiles will have evaporated from this powder, if it is old, creating a corresponding increase in ballistics. This will cause irregular burning and more rapid burning than normal and, if old powder is used in heavy charges, dangerous pressures are likely to result. There is no sense in fooling around with odd lots and old "clucks" of powders when fresh stocks of modern, progressive powders are readily available. The purchase of such lots of Government powder as may be offered for sale from time to rime is only justifiable if you are content to load it in the cartridge it was made for and exactly according to the loading data furnished with it. On the other hand, if you want a powder for general reloading purposes, and especially in other than U. S, Military cartridges, get a powder that is made for the purpose and on which adequate loading information is available. The few cents a pound that you save on the Government powder is no economy if you can't use the powder after you get it, and it costs just as much to *ship* one kind of powder as another.

Shotgun Powders. The ballistic requirements of powders for shotguns are entirely different from those for rifled arms. It is important that when a shot charge leaves the muzzle of the gun there should be relatively little pressure behind it, for if the muzzle pressure be too great, blown patterns will result. A blown pattern is caused by the filler wads driving through the shot charge, scattering the shot laterally and causing a pattern in the form of a ring of scattered shot with few or no shot in the center. To prevent this condition, quick burning powders are necessary and to make these powders burn fast, potassium or barium nitrate are sometimes incorporated in them. Shotgun powders are of two general classes; bulk powders and dense powders. The latter are manufactured in much the same manner as rifle and pistol powders and are usually cut into thin flakes or discs to increase their rate of burning. The bulk powders are made by a precipitation process and the grains take the form of small irregularly shaped lumps, porous and soft in

nature and gelatinized only on their surfaces. Most of the dense shotgun powders are absolutely unsuited for use in rifle or pistol cartridges. Even in reduced loads, they will give relatively high pressures for the low velocities they develop.

The bulk powders, of which there are two manufactured in the United States, are known as duPont Shotgun Smokeless and Hercules E. C. These powders cannot be recommended for use in rifled arms but they can be used in reduced loads in some cartridges with good results. Due to their rapid burning and porous nature, they will develop dangerous pressures if overloaded and as no loading data is regularly available for using them in rifled arms, their use for such purposes should be avoided. The mere fact that a powder *can* be used is no excuse for using it, when safer and more efficient powders are available.

Blank Cartridge Powder. This is a type of powder made especially for blank cartridges. It is extremely fast burning and develops high pressures even in blank cartridges. Loaded behind a bullet, it will almost surely burst any ordinary arm. This powder is not available to reloaders but in spite of this some of it turns up once in a blue moon. If, by any remote chance any of it comes into your possession, destroy it at once. It is not only highly dangerous, but absolutely worthless for reloading purposes. Do not take any chances with it.

Old Powders

Sometimes old cans of powder will turn up and come into one's possession, usually as a gift from someone who used to reload ammunition years before. Such powder may be in good condition but the chances are against it, even though it appears to perform satisfactorily. There is no reason why it should not be used, but it is best to use it in reduced loads for short range shooting. I have some old Laflin & Rand powders that are still very good but I have some others that are not. The double base or nitro-glycerine powders will keep better and longer than nitro-cellulose or single base powders and one should be especially careful when using old lots of the latter type.

Where To Obtain Powder.

Up until about a year ago, powder could only be shipped by freight. There were very severe restrictions and regulations on the way the powder had to be packed and the freight car it went into had to be labeled that it had explosives in it, etc., etc. The freight rate was one and a half times the first class rate and it was necessary to pay freight on one hundred pounds, even though the shipment only consisted of one lousy little canister of powder. Naturally, the freight charges were greatly in excess of the value of the powder, when shipped in small quantities, and it was a pretty tough and expensive job for a reloader to get powder. Thanks largely, and possibly entirely, to Belding & Mull, the Interstate Commerce Commission was finally convinced that smokeless powder was not as dangerous to transport as had been believed, and the shipping regulations have now been changed. SMOKELESS AND SEMI-SMOKELESS powders may now be shipped by express, at regular rates, the only restriction being that not more than ten canisters, containing not more than one pound of powder each, can be shipped in one case. BLACK POWDER MUST STILL BE SHIPPED BY FREIGHT. The change in regulations on the shipment of smokeless powder now makes it possible for the handloader to get about any kind of smokeless he wants, at a reasonable shipping cost.

It is advisable for the reloader to purchase his powder as close to home as he can so as to save as much as possible on the shipping charges. E. I. duPont de Nemours & Co., and The Hercules Powder Co., both of Wilmington, Delaware, are the only two manufacturers of smokeless powders in the country. They also manufacture black powder. Both companies have distributing points in various parts of the country, so by writing them, one can determine the most convenient point from which to order powder. Most, if not all, of the reloading tool manufacturers also carry stocks of powder. The Lyman Gun Sight Corp., endeavors to maintain an up-to-date list of dealers throughout the country who carry stocks of powders and cater to the needs of the handloader and it is entirely possible that other manufacturers of loading tools do likewise. The reader will do well, when in need of powder, to communicate with one or all of the firms mentioned, but first (and this may sound silly) inquire of your local sporting goods dealers, if any. I have on many occasions received requests for sources of supply for powders from localities where powder was readily available.

Semi-smokeless powder can be obtained from the King Powder Co., King's Mills, Ohio. As far as I know, this firm has no other distributing point but some dealers carry semi-smokeless in stock. In writing for sources of supply, be sure to give the name of the nearest large city, if you live in a small community, as dealers in small towns seldom find it worthwhile to carry powder in stock or to handle it at all.

The Care and Storage of Powder

The saltpeter, sulphur and charcoal from which black powder is made are all capable of absorbing considerable quantities of atmospheric moisture and combining them into powder does not reduce their absorbent qualities. The graphite with which black powder grains are often coated helps to exclude moisture but does not absolutely prevent its absorption. Black powder is completely ruined by water and even though it only becomes damp, it will not regain its original strength when it dries out. Moisture causes some of the saltpeter to dissolve and this saltpeter crystallizes out when the powder dries, destroying the original intimate mixture of the ingredients. The old adage, “keep - your powder dry,” is well applied to the storage of black powder. It must be kept dry, but the temperature under which it is stored is not important, so long as it does not approach the combustion point of the powder, of course. This point is way above the temperature of the hottest attic in summer so it is safe to say that the handloader can keep his black powder in any dry place away from fire. Black powder is a mechanical mixture and contains no solvents or volatiles that affect its burning rate.

Smokeless powder presents a set of conditions almost the reverse of those affecting the storage of black powder. In the first place, smokeless powder is not affected by moisture. Of course it cannot be fired when wet, but wetting it and drying it out does not affect its ballistic properties. In fact, one of the best ways to store smokeless powder for long periods of time is to immerse it in water. This method of storing powder is fairly new and was discovered quite by accident. A sunken French battle ship was raised after many years, during which the magazines had been full of salt water. Powder from these magazines, when dried out and tested, was found to

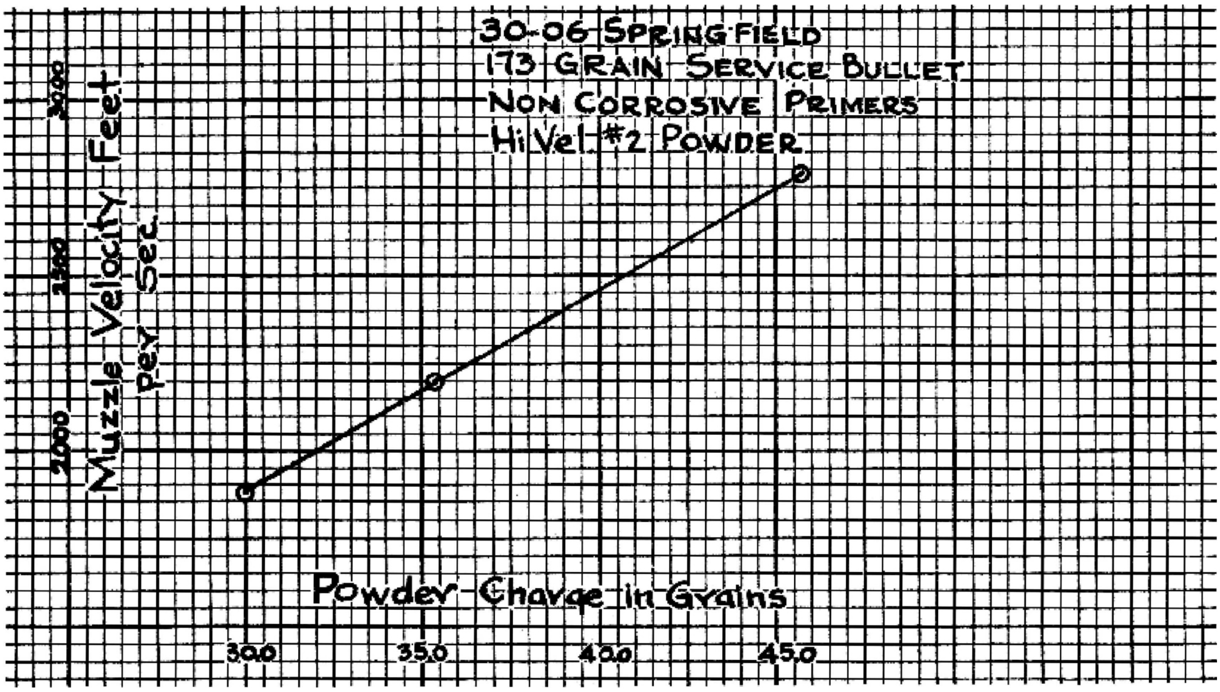
give practically the same ballistics as when the powder was made many years before. This instance has led to the under-water storage of military powders, the use of which may not be required for years.

It has already been painted out that in making smokeless powders, all of the solvents and volatiles cannot be recovered from them and that the percentage of volatiles in them has a direct bearing upon the performance of the powder. Heat will drive these volatiles out rapidly, leaving the grains porous and greatly accelerating the rate of burning. Storage under water keeps the temperature of the powder down and prevents it from drying out. Where powder must be kept in readiness for instant use, underwater storage is out of the question. Ordinarily, such powder is kept in hermetically sealed containers which are stored in easily accessible magazines. These magazines are well ventilated and sometimes are provided with means for keeping the temperature at an even level. 70º F. is considered about ideal and most ballistic tests are made with the powder at this temperature, but smokeless powder will stand very low temperatures. It will not remain stable at high temperatures and the reloader should keep his smokeless powders where the temperature never exceeds 90º F.; preferably, but not necessarily, in a dry place. The choice between a hot dry attic and a damp cool cellar should be the damp cellar for smokeless powder, and the hot attic for black powder. If the powder must be kept in a damp place, small gaskets of cork or rubber should be made for the canisters and the lids screwed firmly down against them.

But after all, why worry about hot attics or damp cellars? Our American powders are remarkably stable and if kept in a room where the temperature is livable they will keep almost indefinitely.

Determination of Charges by Interpolation.

The powder companies' tables can be used to verify charges obtained from other sources, just as the spelling of a word may be verified from a dictionary. The usefulness of these tables is by no means limited to the simple procedure of picking a charge out from among those listed. As most of these tables give more than one charge for each weight of bullet for each caliber, and the difference between such loads is represented only by the difference in the weights of powder charges, a fairly accurate charge and velocity curve can be plotted from them. To do this, the vertical edge of a sheet of cross-section paper is marked off in increments of velocity in feet per second, within the limits of the loads in the table; then the horizontal side of the squares in increments of weights of charge, also within the limits of charges shown in the table. Dots can then be placed on the intersections of the horizontal and vertical lines, representing the charge and velocity for each load, and connected by straight lines. If only two points are used, the "curve" will be a straight line and more than two points will give an angular line but this can be smoothed out into a regular curve beginning at the lowest point and terminating at the highest one, passing through any intermediate points. One can then read off the velocity of any charge of that powder for the cartridge and bullet it pertains to and the velocity figure obtained in this way will be quite accurate. It is useless to do this with loads taken from several different tables; they must all be from the same table and for the same caliber of cartridge and weight of bullet, if only the bullet weight is given, or for the same make, weight and kind of bullet if possible. Every condition must be exactly the same, except the weights of the charges.



The curve shown above has been plotted directly from one of the Hercules powder leaflets as explained on opposite page. This is the correct method of determining the ballistics of a charge used which lies between the published charges found in the powder leaflets. It is also the best way of determining what charge to load for a definite velocity when data is available covering the ballistics of higher and lower charges. The frontispiece illustrates how velocity and pressure curves may also be plotted and ascertained.

Extending the curve beyond the plotted points will not give accurate results and it is of little use to do this, as the highest charge given in the table is probably the heaviest one that should be loaded anyway.

This can also be done with pressures, making the curve a charge and pressure one, but there is absolutely no reason for making such a curve. As long as the pressure is safe, who cares what it is? IF A CHARGE AND PRESSURE CURVE IS PLOTTED FROM A POWDER TABLE, UNDER NO CIRCUMSTANCES SHOULD THE CURVE BE EXTENDED BEYOND THE HIGHEST

CHARGE POINT. NO ONE CAN PREDICT WHAT WILL HAPPEN BEYOND THIS POINT. The heaviest loads in the tables should only be used with the greatest care and with new cases. Even new cases are not infallible, for once in a while they will give way near the heads because of some hidden defect that could not be seen by the inspectors. The illustration on Plate XVI shows two failures of this kind that occurred with normal factory loaded ammunition. Both were fired in bolt action rifles and both resulted in eye burns from the gas escaping back through the bolts. If you *must* load the heaviest permissible charges into your cartridges, by all means use new cases and answer the following questions to yourself before going ahead with the loading.

1. Are my bullets of the same diameter, weight and hardness as those used in establishing the load?
2. Are the bore and groove dimensions and the throating of my gun the same as those of the test gun?
3. Do I know the correct depth to which the bullets should be seated?
4. Are my cases of the same inside shape and the same capacity as those used in developing the toad?
5. Are the vents of my cases the same diameter as those of the cases with which the load was developed?
6. Are my primers correct for the vent size of my cases and will they give the same order of ignition as those used by the powder manufacturer?
7. Is the chambering of my barrel the same as that of the test barrel and especially, is it the same diameter at the neck?
8. Is my gun breeched up properly and in safe condition to use with heavy loads?

If you can answer all of those questions in the affirmative you can, by careful loading, duplicate the ballistics of the load in the table of charges. I might even say that if you can answer all of those questions in the affirmative, you are a magician. The sole point in listing them is to show that duplicating the results shown in a table of charges takes a lot more than just using the same kind of a bullet and being careful with the weights of the powder charges. It is best to keep the weights of charges just a little less than those shown in the tables when the heaviest loads are used, for a little shading in the charge will not cause much loss of velocity but it will ease up the pressures and allow for the variables in components that the reloader has no means of detecting.

Variations in Components.

The variations in components that will cause increases in pressure may be summarized as follows;

1. Enlarged vent in the cartridge case permitting more of the primer flash to reach the charge thereby increasing the initial rate of burning. This will also increase the back thrust of the primer itself, due to higher pressure than normal within the primer pocket.
2. The use of a hotter primer than the vent is designed for will also increase the initial rate of burning of the charge.
3. The use of too much of the right kind of powder. The increase in the total burning area and decrease in the air space will cause the pressure to accelerate more rapidly than normal and to reach a higher point before the bullet has had time to move forward.
4. The use of too fine or too fast burning powder in heavy charges. This refers particularly to powders for pistols or small rifle cartridges when used in the larger rifle cartridges. Such powders are useful in reduced loads but if charges are increased too much, the pressures will develop so rapidly that they will practically cause all of the powder to burn at once. A slight over-load of these powders is far more dangerous than with the coarser grained and slower burning powders.
5. The use of a heavier bullet than normal. The heavier the bullet, the greater the time and force required to overcome its inertia.
6. A larger bullet than normal. An increase in the bullet diameter will increase the force and time necessary to impress it into the rifling and will also increase the friction between it and the barrel.
7. A harder bullet will increase pressures for the reasons already mentioned. However, the variations in hardness of factory jacketed bullets can be ignored with all normal loads. In revolvers, soft bullets are more dangerous than hard ones with heavy loads, as soft bullets up-set greatly between barrels and cylinders.
8. A longer bullet than normal will cause some increase in pressure because of the greater bearing surface but this condition does not have any effect until *after* the bullet has started forward. As an increase in length would of necessity be accompanied by an increase in weight also, the condition in paragraph 5 would apply.

Another factor of importance in connection with the use of heavy loads is the arm itself. I refer now to the type of arm. It must be borne in mind that when one is shooting a bolt action rifle, the shooter's face is somewhat removed from the head of the cartridge. If a break occurs in the head of a case or a primer is pierced, the escaping gas must pass back through or around the bolt, where there are various mechanical parts to help impede and deflect it. This is not true of most single shot rifles. When shooting these arms the shooter's face is right up on top of the cartridge and when something does let go, it is likely to be just too bad. Bushed firing pins or other trick alterations of the firing mechanism may be of some use in supporting the normal thrust of the cartridge case and primer, but when the case gives way these gadgets are just so many more pieces to fly around.

Revolvers and pistols are not so bad when they blow up, as they are held well away from the face of the firer. Fortunately, the force of explosion and the direction of the flying pieces is lateral and upward for the most part. Pieces seldom come to the rear, although they can, and the most that a shooter is likely to lose is a finger or two off his gun hand, which isn't so bad as he will still have six left. But eyes are different; we only have one of these to spare and it seems a pity that handloaders should risk them by following the guff and ballyhoo of the barnyard ballisticians, who, like children in a sand box, fill cartridge cases up with powder, get away with it by the grace of God, and then loudly proclaim to the world that the ballistic engineers of the powder companies don't know what they're talking about.

The illustration on Plate XI shows the top of a cylinder of a revolver, blown up with overloaded, reloaded ammunition. Whether the owner just didn't know what he was doing or whether he was following some information received from unreliable sources, I don't know, but he sure did a good job. Note that the “blow” was not caused by one overloaded cartridge. The gas pressure, or the set-back from the cartridge fired, fired the cartridges on either side of it. Had the cartridges in the chambers on either side of the one fired in

the usual manner, been normal loads, it is unlikely that the top would have been completely lifted off the cylinder. Even if it had been, there would have been no expansion of the side chambers, but you can see that both of these chambers are expanded from the overloads that they contained.

If you must fool around with these crazy loads, be philosophical about it if you get injured or maimed. Charge the damage off to experience, get a new gun, and use better judgment in the future.

* * *

I am closing this chapter on powders with the expressed hope that no reader feels disappointed because there has not been included several yards of printed tabulations showing all the "recommended" charges for the various cartridges with all the smokeless powders dating back to the time of the Spanish-American War. I could have copied these off from various sources, but decided not to. Instead, let me again urge the reader to write the powder manufacturers and get from them the latest descriptive folders giving a list of charges for the cartridges he is interested in. Then obtain a supply of cross-section paper, ruled in tenths of an inch, in order to be able to plot down and interpolate any number of *safe* loads from the charges given in these folders; using the method described on page 51 and illustrated on page 51.

I have the most profound respect for these little duPont and Hercules powder folders. The information in them is authentic and accurate, they tell so many stories, when carefully analyzed, that their usefulness goes far beyond the superficiality of a list of charges which can be lifted out, body and breeches, and loaded into cartridges. Within their limits, they offer the handloader all the facilities of a ballistic laboratory, without the fuss, bother and expense of doing the work.

CHAPTER FOUR

BULLETS.

The first missiles fired from arms using gun powder as a propellant were probably stone and we do know that cast iron balls were used in the early history of such arms, but as neither of these substances are of any use to us for reloading ammunition we can jump forward to the use of lead or alloys of this metal.

Smooth bore, muzzle loading muskets used lead balls— that is—the projectiles were approximately spheres or balls before they were loaded. These arms were notoriously inaccurate, because the "balls" had to be smaller than the bore in order to load them and when fired, bore harder on one side of the barrel than the other, causing them to take a flight like a pitcher's curved ball. As their direction of rotation was a matter of chance, both as to degree and direction, the shooting was erratic. Difficulty was encountered in making these balls stay down on the powder charge. The "Brown Bess" was the standard arm of the British forces during the American Revolution, and each British soldier was issued an iron mallet which was used to hammer the end of the ramrod and upset the ball enough to keep it in place. This upsetting, or flattening of the ball, may have reduced its tendency to roll, but it made it scale instead. Fifty yards was about the greatest distance at which a mark the size of a man could be hit with any certainty with these smooth bore muskets. This led to the adoption of a range finding system in battle that consisted of holding the fire until the whites of the enemy's eyes could be seen. For average eyes this distance is just about fifty yards.

The idea of using spiral grooves, or rifling, in a barrel to impart rotation to a bullet and keep it stable in flight, is lost in antiquity. The difficulty in doing this was that the bullet had to be small enough to be pushed down the bore and still be large enough to fill the grooves after it got there. This difficulty was overcome by some unsung colonial gunsmith or rifleman by using a ball smaller than the bore, covered with a patch of sufficient thickness to fill the grooves, the soft patch being compressed into the grooves as the ball was forced down the bore. When the arm was fired, the patch followed the rifling, imparting rotation to the ball but left the ball on passing out of the muzzle. The ball, un-deformed, continued to rotate as it sped on its way. This condition could be duplicated with each shot and the improvement in accuracy over the old smooth bores was remarkable. Some of these old muzzle loading rifles could, and still can, show a degree of accuracy, within the limits of their effective range, that can be exceeded only by the very best of our modern rifles. The popular belief that all of the old muzzle loading rifles were extremely accurate is fallacious. Much depended upon the rifle and much more upon the shooter. There were undoubtedly "gun bugs" in the days of the muzzle loaders just as there are today, and it is but natural that those who studied their arms and the loading of them, and sought the products of the best gunsmiths, should get the best results.

Buckskin and linen were the two materials used for patches, because they were the only suitable materials available at the time, but today a variety of cotton fabrics can be used with excellent results.

When breech loaders came into use, the need for a patched bullet or ball was no longer necessary, as it was then possible to use a bullet large enough to fill the grooves of the rifling, inasmuch as the bullet was seated behind the rifling, instead of being forced down the bore from the muzzle. As a naked and un-lubricated lead bullet will quickly lead a barrel and render it inaccurate, bullets were provided with grooves, or cannelures, which were filled with lubricant. But the use of patches did not disappear for a long time, although their form changed from those used in the old Kentucky rifles, nor did muzzle loading cease to be practiced.

Patched Bullets

Paper patched bullets were in quire common use when the writer began his shooting career and could be purchased from any of the ammunition companies for reloading purposes. These bullets were either loaded into the cases and used just as our present day ammunition is used, or they were seated into the barrel the proper distance with a bullet seater, after which the case, charged with powder, was put into the chamber behind them. Many records were made with arms loaded in this way and today many of the old Schutzen rifles are being resurrected, with surprising results to some of the boys to whom the smell of black powder is a novelty.

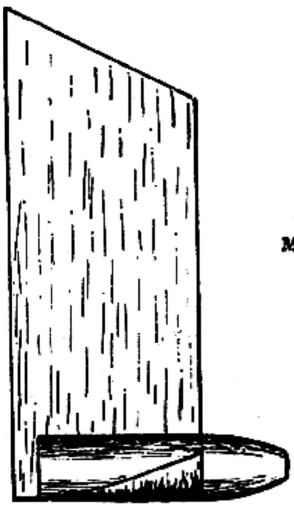
Because of this resurrection and the difficulty of finding information on methods of patching bullets, a description of the procedure is given here. Be it understood that the writer never put a paper patch on a bullet in his life and that the following comments are taken from the experience of honorable and straight shooting gentlemen who did do it and knew how.

Paper-patching Bullets. "Bullets to be patched with paper are smooth, without grooves. They are from three to six thousandths of an inch smaller than the standard size. The diameter is increased to the size desired by having a thin paper patch rolled around them, covering about two thirds of the bullet from the base up. The paper should be of fine, strong texture, similar to bank note paper. (Note: When paper patched bullets were popular, a special grade of paper was made for patching them and came in four thicknesses; extra thin, thin, medium, and thick. The extra thin was about ·0015 thick and there was an increase of about a half thousandth of an inch in each succeeding size.) Shooters wishing to increase or decrease the diameter of their bullets can do so by using the proper thickness of paper. There is a difference of opinion relative to the advantage or superiority of patched bullets over grooved, yet for hunting or military purposes the grooved ball is generally preferred, as such ammunition can be carried and exposed to wet weather without injury; while a part of the patch being exposed is liable to get wet and injured so as to impair its accuracy. Still, for fine target-shooting, the patched bullet properly handled is, without doubt, preferable.

The ordinary factory patched bullets have *two* laps of paper around them. The patch is cut in length so that the ends do not lap over but almost butt up to each other. The regular patch is cut on an angle of about 35 or 40 degrees, as shown in the cut. This angle is so that the joining of the laps will not be parallel with the rifling or the axis of the bullet, thus holding the patch over both points of the lap.

How to Fit Patch. First cut a strip of paper the width desired; have it long enough to lap *three* times; roll firmly about the body of the bullet; have edge of paper even with base of bullet; when so rolled, hold point of bullet from you and with the point of a sharp knife cut through all the thicknesses of paper *except* about a sixteenth of an inch at the base; commence cutting from the point toward the base, scribing the angle desired around the circumference of the bullet. When unrolled the *two inner full-sized pieces* that are held together by the uncut part will represent, *when put together,* the shape and length of patch desired, except the cutting off of about one sixty-fourth of an inch in length, preserving the same angle, thus preventing the possibility of the ends lapping over. When the patch is found to be correct, a piece of sheet metal can be filed up to the shape and size, to be used as a template or pattern to cut others.

Before putting the patches on, it will be well to dampen them between two wet cloths, so as to take the crisp out of the paper. This will also cause it to lay snugly to the ball and help in the matter of closing the paper over the base, which when perfectly dried will have shrunk firmly to the bullet. *Do not* make patches too wet, or use mucilage or any sticky substance, for patches *must leave the bullet clean* at departure from the rifle.



Method of Rolling Patch.

How to Roll Patch. Lay the patch on a smooth board or table with the point of one of the angles toward you and to your *right;* let the whole of the angle project over the edge of the board or table (this will leave the point of the patch free, not stuck down to the table); then place the bullet squarely on the patch (base to the left), letting as much of the paper project beyond the base as you desire. When the bullet is in position, turn the projecting point of the patch up over the bullet and, with a forward push, roll the bullet up on the patch. If the patch is not rolling on straight, roll the bullet back, readjust it, and try again. With a little practice this can be done accurately every time.

Paper patched factory bullets used to be made with a hollow in the bases. With such bullets, the patch should project beyond the base of the bullet about two thirds of the bullet diameter. This projecting paper is twisted up and pressed into the base cavity.

With flat base bullets, allow the patch to project only *one third* of the diameter of the bullet, turn the paper in over the base of the bullet and press the base of the bullet on the table. This will leave the center of the base of the bullet bare.

The Chase Patch. This is a square end patch, wrapped only once around the bullet with the ends just butting together. The patch is wrapped around the bullet with its edge just flush with the base of the bullet, the patch lapping only once around the bullet. The patch is inserted in the Schutzen bullet seater, it should project beyond the mouth of the case that forms part of the bullet seater. It may be squared up by pressing gently against the plunger of the bullet seater so as to form a cylindrical tube. Insert the bullet inside of the patch so that both the rear of the patch and the base of the bullet are against the plunger; patch and bullet are seated in the barrel ahead of the case to the desired depth. This method of patching is impractical except for fine target shooting but it has made some of the best records ever obtained. Dry, crisp paper is used for making the Chase Patch.

In seating regular patched bullets in the shell (in the ordinary manner) some shooters used to use a thin wad over the powder, then a disc of lubricant on top of the wad with the bullet on top. Others seated the bullet on top of the powder without wad or lubricant,

wiping the bore out after each shot. Experience must decide these points for each shooter." (The body of the foregoing, if not the breeches, has with some modifications, been taken from an old Ideal Hand Book.)

For the benefit of the younger generation, a Schutzen bullet seater is a device for seating bullets in the barrels of rifles, independently of the cartridge case. It takes the form of a cartridge case of the same caliber as the rifle, with a sliding plunger inside actuated by an extended handle, usually off-set for convenience. The travel of the plunger may be definitely fixed or may be adjustable to provide seating the bullets in the barrel to any desired depth. The bullet is inserted in the mouth of the case, the case inserted in the chamber, and the plunger forced forward to the limit of its stop. The case, charged with powder, was inserted after the bullet was seated. This is essentially the same method that is employed in loading large caliber cannon today, as is described elsewhere in this book.

Cast Bullets.

There are two methods of making lead or lead alloy bullets; one is to cast them in moulds and the other is to swage them to shape. The latter method is used in making factory bullets, it makes a bullet of more uniform shape and density than can be made by casting. A slug is first cast in a mould or is cut from lead wire of a suitable size. These slugs are rammed into a die having the profile of the bullet, but without grooves, under heavy pressure. The slugs are of a greater volume than the die into which they are forced and the excess metal is squeezed out through a small hole in the side of the die, in the form of a fine wire known as "weep". This insures full and uniform bullets. The slugs or cores of jacketed and soft point bullets are made in the same way. After the bullets come from the die they are rumbled to remove the oil, as well as any burrs from them, after which the grooves are rolled into them and they are sized to the correct diameter.

The method of casting bullets has been described elsewhere but as this type of bullet is the one that the reloader depends on for economical shooting and is used extensively, some space will be devoted here to a few side lights on it. Cast bullets are of three general types; flat base, hollow base, and gas-check base.

Flat Base Bullets. The flat base bullet, as its name implies, has a flat base that is the full diameter of the bullet. Moulds for this type of bullet are made so that the cut-off is at the base of the bullet and it is necessary that the cut-off screw be tight and that the cut-off fits flat on the top surface of the mould to cast these bullets correctly. When black powder was the only powder available, bullets were often made smaller than the groove diameters of the barrels they were used in and the expansion of the base under the sudden thrust of the powder gasses was depended upon to fill the rifling. Many of the old black powder arms had rifling grooves much deeper than are found in modern arms and some would not accommodate cartridges loaded with bullets that were the full groove diameter. This condition is seldom found in present day arms, the noteworthy exceptions being the ·256 Newton, 6·5 Mauser and Mannlicher and some 8 m/m Mausers.

Some plain base bullets were also made with a bevel on the edge of the base. In the deep rifling of the older arms, fins were pushed back over the edge of the bullet base as it was impressed into the rifling and these fins were detrimental to the best of accuracy. The bevel on the base of the bullet prevented this occurrence but unless the bevel was perfect, no advantage was gained by it. As most modern rifles are made for jacketed bullets, the grooves are relatively shallow. Such slight fins as may be formed on bullets with square, sharp bases are probably blown off by the muzzle blast. At least, this factor is no longer considered of consequence. If a flat base bullet is very much larger than the groove diameter of the barrel it is fired in, metal must be pushed back all around the entire base of the bullet and this doesn't help the accuracy any.

Hollow Base Bullets. Moulds for hollow base bullets are made to cast the bullets with the points, or rather the noses toward the cut-off and for this reason must have flat noses. It is impossible to make a mould to cast a pointed bullet with a hollow base. Hollow base bullets are only used in revolvers and, except for deep seating bullets, there is neither excuse nor reason for such bullets in modern revolvers. Early revolver cartridges used bullets that were the same diameter as the cartridge case, having heels on the rear ends that fitted tightly inside of the cases. They were crimped by a rolling operation, which cannot be duplicated in a handloading tool. These bullets were lubricated on the outside by dipping the bullets into melted lubricant after the cartridges were loaded. Most rim-fire cartridges are still made in this way. The outside lubrication was messy and picked up dirt and grit, furthermore, the heels on the bullet bases did not expand or upset uniformly and the accuracy that could be obtained from outside lubricated cartridges was, at best, limited; the tales in dime novels notwithstanding. To overcome the objections of the outside lubricated bullet, grooves were made in the body of the bullet and the bullet was made small enough to fit *inside* of the case to a depth that would permit the lubrication grooves to be completely covered. This meant an increase in the length of the cartridge case and a very considerable reduction in the bullet diameter; a reduction so great that inside lubricated bullets will drop right through the barrels of revolvers made to shoot the outside lubricated bullet. Something had to be done to make the smaller bullets take the rifling, so deep concavities were put in the bullet bases to facilitate their expansion.

About the only revolvers in common use today that were made for outside lubricated bullets, are the old Colt and Smith & Wesson Model 1901 army revolvers that were sold by the Director of Civilian Marksmanship a few years ago for $5.50 each. Thousands of these guns are in the hands of shooters. They were made to use the old ·38 Long, outside lubricated cartridge and the chambers are practically straight reamed holes. Cartridge cases are no longer obtainable and those for the ·38 Long I.L. cartridge will not take the old heel bullets. They will take them, but will not hold them. The barrels are entirely too large for plain base, inside lubricated bullets. Hollow base conical bullets are no good in them with smokeless powder and not much good with black powder. I have fooled around with these old clucks off and on for a good many years but, until quite recently, I never did get one to shoot well enough to bother loading the ammunition for it. One day about a year ago, I received a letter from some fellow who had a model 1901 revolver. It was the only gun he had and I judged from his letter that there wasn't much chance of his getting another, so I didn't have the heart to advise him to hang it up over the mantle as a relic. He wanted a wad-cutter load for it which gave me an idea so I cast up some of Ed. McGivern's bullet (Ideal No. 358395) of a soft alloy and loaded them pretty well out of the cases with all the FFg black powder I could get behind them. The combination of the long, cylindrical bullet with the easily expanded hollow base did the trick and the load shot very well; far better than any other load I have ever used in this gun.

Hollow base bullets should not be used in revolvers with heavy loads. If fired from a revolver with the barrel removed, the hollow base will be literally turned inside out if the bullet is soft, and if it is hard, the base portion will be blown off entirely. Incidentally, the

threaded part of the frame, where the barrel is screwed in, will be so nicely leaded that, in the absence of a thread chaser to clean the lead out of the threads, the gun will probably have to go back to the factory before the barrel can be replaced.

Fired in a normal gun, the hollow base will expand between the barrel and cylinder and in the beveled rear portion of the barrel. This results in a check in its free forward movement, similar to encountering an obstruction, and causes the pressure to rise excessively. With normal loads, this rise in pressure is not enough to cause any harm but with heavy loads, such as are sometimes mentioned in magazine articles (but are never recommended by the companies that make the powders) a hollow base bullet may well cause pressures to rise to a point that will strain or burst the gun. In speaking of hollow base bullets I refer to these gosh-awful monstrosities with a hollow that one can hide in. If the concavity is merely a shallow depression of but a few hundredths of an inch deep, such as are found in *some* factory bullets, they will do no particular harm.

Gas-Check Bullets. These bullets have a heel on their bases over which shallow gilding metal cups or gas checks fit. They may be fired with heavier charges of powder than plain base bullets, the gas checks acting as a protection against the extra heat and pressure of such loads. Gas check bullets can also be used with some powders that are not suited to plain base bullets of the same caliber. This permits them to be fired at higher velocities than plain base bullets.

The question is often brought up as to how fast a gas check bullet may be driven with good accuracy and without fusing. (Stripping or fusion of the bullet does not occur until the bullet fuses or melts on the outside, from the heat of the gasses forcing past it.) The Ideal Hand Book has long published the figure of 1800 f.s. as the maximum velocity for gas check bullets but this, while a fair average for all such bullets and a velocity at which good accuracy can be obtained almost with certainty, is conservative in many instances. Good accuracy has been obtained with some bullets of this type at as high as 2400 f.s., without leading the barrel but others will cause difficulties at much lower velocities. There just is no fixed rule and the reloader who wishes to get the highest velocity possible with a gas check bullet will have to do some experimenting. One shot will not tell anything and to find such a load with a minimum of shooting, the rifle should first be fired sufficiently to foul the barrel and clean out all traces of oil. Next load and fire three cartridges, using a load that is fairly conservative to begin with and shoot for accuracy on a target. If the three shots group well, the charge in the next three cartridges can be increased. After each series of shots examine the barrel carefully for signs of leading, particularly near the muzzle. This may be seen as lumpy patches or streaks in the early stages, but with excessively heavy loads, the lead may cover the entire bore evenly and not be seen at all, except by the practiced eye. In this case there will be a splash of lead all around the muzzle. When the load is worked up to a point where leading occurs, the accuracy will probably go to the devil and an enlargement of the groups will usually occur before this point is reached. Keep a memorandum of the loads tried and when it appears that the accuracy is decreasing, stop.

The work thus far has been a crude approximation and before going further it will be necessary to clean the gun. If there are no visible signs of leading, scrubbing the bore out with a brass brush and nitro solvent will be sufficient. If leading is present, scrub the bore with a *dry* brass brush. If the brush has previously had oil or nitro solvent on it, wash it in gasoline or carbon tetrachloride before using it. Then plug the chamber with a *tight* fitting cork or wooden plug, fill the bore with metallic mercury and let it stand for a couple of hours; pour the mercury out and wipe the bore clean with a *dry* patch and examine it for signs of lead. If the lead is not all out, repeat the process. The word "dry" is emphasized because even a slight trace of oil on the leaded surface will prevent the mercury from picking the lead up. I know of nothing besides metallic mercury that will thoroughly remove a good dose of lead from a barrel and if the lead is not *all* removed, it will quickly pick up more lead when the gun is fired again. Also be sure that the cork is driven into the chamber tightly, for mercury is heavy and when poured down a barrel it lands on the cork with a severe jolt. If the cork comes out, you *will* have a mess on your hands. Mercury can be obtained from any wholesale drug or dental supply house in small, one pound jugs and it is handy stuff to have around if one uses lead bullets. It will also take out the fouling of metal jacketed bullets and can be saved and used over and over again.

When the barrel is clean, select the heaviest load that gave good apparent accuracy with three shots and load up twenty cartridges, firing them for accuracy. If the accuracy holds up for twenty shots and does not show more than slight traces of leading, you probably have the heaviest load that can be fired satisfactorily *in your rifle.* It does not necessarily hold that the same load will be good in another rifle of the same caliber. The alloy used, the individual mould, the bullet size, the lubricant used, the bore and groove dimensions of the barrel and the throating all enter into this as well as the kind of powder, which makes it impossible to lay down any fixed limit of velocity for any bullet and arm. Sure, it's a lot of work, but the fellow who wants the last fraction of an inch of muzzle velocity with a cast bullet can't expect to get it by sitting in a rocking chair and reading a book.

A question that is often asked about gas check bullets is: Can they be used without the gas checks and with good accuracy? The answer to this, like the answer to most questions regarding the loading or reloading of ammunition, is yes and no. A gas check bullet has a heel on the base to which the gas check is fitted and this heel is considerably smaller than the bearing surface of the bullet. Used without the gas checks, the true or effective base of the bullet becomes the exposed surface of the first band and the heel becomes a nuisance, for if the heel upsets irregularly, the muzzle blast, impinging on it after the bullet has left the muzzle of the barrel, will cause some deflection. The difference between the diameter of the heel and that of the bearing surface of the bullet is too great to expect the heel to expand to the groove diameter of the barrel with any charge of powder that can properly be used with a plain base bullet. The heel is stubby and the gasses act around the outside of it as well as against the rear and while no definite rule can be given, it is best to use a fairly hard alloy for casting the bullets, then they will usually give excellent results with powder charges suitable for plain base bullets when fired without their gas check cups.

The ·22 Long Rifle and other rim fire cartridges have rather long heels that fit the inside of the cartridge case and one of the problems in loading this type of cartridge is to cause this heel to expand uniformly to the full groove diameter of the barrel. This necessitates using a bullet alloy soft enough to expand with the particular powder and charge with which the ammunition is loaded. As the heels of rim fire bullets are relatively longer and larger than those of gas check bullets, the problems of loading the two types are entirely different.

Gas checks must be quite shallow and their function is limited to protecting the base of the bullet and preventing gasses from melting or getting past the base. If they are made deep, they become in effect bullet jackets and present problems that cannot be overcome with ordinary handloading tools. The writer has done at least a limited amount of experimenting with deep gas checks and the results have been very unsatisfactory. It is impracticable, if not impossible, to get a tight enough assembly between the cups and

the bullets to prevent some slippage between the two when the bullets are fired, by using any lubricator and sizer or bullet sizing tool. If there is slippage between a deep gas check and the bullet, or between the jacket of a bullet and its core, the accuracy will be poor.

Gas checks can be put on bullets by tapping them on to the bullet bases with a stick but the usual way is to push the gas checks onto the bullets as well as possible with the fingers or press the bases into the cups laid open side up on a table. The seating is completed when the bullets are forced, base first, through the bullet sizing die.

Most gas checks have slightly rounded bases and when lubricating them in one of the lubricators and sizers, grease is apt to force its way under the bullet bases unless a recessed inside punch is used to close the gap between the rounded edge of the gas check and the top of the punch. Plain base bullets require an inside punch with a flat surface. I expect that the next few years will find gas check cups made with flat bases, which is the proper way to make them although the present ones work all right.

Hollow Point Bullets. These bullets are cast from the base and may be either plain base or gas check. The hollow point is formed by a slender plug which passes through the base of the mould block, through the point end of the cavity into which it projects. The plug is inserted before the bullet metal is poured into the mould and is withdrawn before the mould is opened. To make such a mould, a drill bushing is necessary. This bushing takes the form of a steel bullet, exactly the same shape and size as the mould cavity, with a hole the size of the drill passing through its center. The hole is drilled and reamed first and the bushing turned and ground on an arbor, so it will be concentric with the hole. The mould blocks are cherried in the usual manner and to a point where the bushing fits the cavity perfectly; then the hole for the hollow point plug is drilled, the bushing serving to guide the drill. This is the only way a hollow point mould can be made or drilled to insure that the hollow point will be in the center of the bullet. Manufacturers can only make hollow point moulds for those bullets for which they have bushings, and they will not make these bushings for any bullet, simply to make up one or two moulds, as the bushings are expensive to make properly. Bear in mind that a bullet, normally pointed, will have the point removed if the mould is made in hollow point form.

Hollow point, in common with hollow base bullets, are a little less convenient to cast than solid bullets. It behooves the caster to work as rapidly as convenient when casting either of them, as the metal must flow into a rather narrow space around the plugs and the plugs, being of small bulk, chill more rapidly than the rest of the mould. Hollow point plugs are slightly tapered to permit their easy withdrawal.

Hollow point bullets are effective for hunting purposes. Their expansion depends upon their hardness, the velocity at which they are driven, or more properly, the velocity at which they strike, and the depth and diameter of the hollow point. At low velocities, the bullets should be soft. On small game that is going to be eaten, solid bullets are usually best as hollow points destroy too much meat. On the larger animals, the bullets should be hard, with hollow points that are not too deep. If the hollow is too deep the bullet will expand too quickly, causing a large surface wound but lacking penetration; a shallower hollow will permit the point to expand but leave a heavier solid body behind the expanded point to push it on, thereby causing a smaller but deeper wound.

The depth of the hollow point in a cast bullet can be decreased by filing off the end of the hollow point plug, but as this plug is shortened, the weight of the bullet will be increased. Hollow pointing removes weight from the front end of the bullet and moves the center of gravity back toward the base, which is beneficial rather than detrimental to good accuracy. Some bullets that are not particularly accurate when cast solid, are very accurate when cast with hollow points.

Hollow point cast bullets cannot be depended upon to break up completely on impact as they cannot be driven at high enough velocities to insure this. The safest bullets for use in settled communities are light weight, jacketed bullets with hollow points, driven at the highest velocities possible with safe pressures. Any attempt to make a cast bullet with a hollow point wide and deep enough to cause it to go to pieces upon impact with the ground, or any substantial object, would be of such poor ballistic shape that it would not be accurate at other than short distances.

There is no reason for making a very deep hollow point in a bullet. As the term implies the hollow should be in the point rather than in the body of the bullet. To determine how deep the hollow could be made in a plain base revolver bullet without danger of the bullet blowing through at the base, the hollow points of some bullets were deepened by drilling them out, a flat end drill being used to bottom the holes. The picture on Plate XIII shows the result. As the hollow became too deep, the bullet slugged out of shape and finally the base blew out, blowing the tapered forward portion of the bullet out to a cylindrical form after which the gasses got around the outside of the bullet and collapsed it. A base thickness of at least ·100 inch should be left to prevent it from blowing out and with only this thickness the accuracy will be destroyed anyway. I repeat that hollows should be limited to the points of bullets.

An old trick and a good one for casting expanding point bullets with a mould for a solid bullet is as follows; lay a strip of thin bond paper across the inside surface of the mould block in such a way that when the mould is closed, the paper will form a septum or division in the point end of the bullet cavity. When the bullet is cast, the paper can be pulled out or torn off leaving a fine slit in the bullet point, but preserving the original shape of the bullet. The depth of the slit can be controlled by the location of the paper strip. If the bullets are soft and they are driven at a fairly high velocity there is a tendency for the points to open up in flight, especially if the slits are deep. To avoid this, the paper strips can be cut narrow and laid across the mould cavity in such a way that a small part of the nose or point of the bullet will be cast solid, the paper strip being entirely surrounded by lead as the bullet comes from the mould. The solid tip will hold the bullet together in flight but will not prevent the point from expanding on impact. By varying the bullet hardness and the depth and location of the slit, almost any degree of expansion may be obtained. The paper between the mould blocks will slightly enlarge the bullet, but as the enlargement will be equal on the opposing sides of the bullet, it can be sized without throwing it off center.

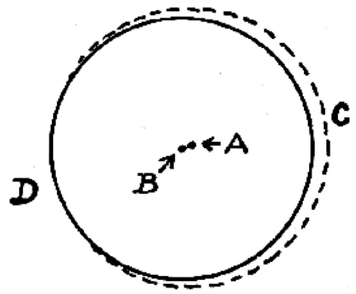
Sizing Cast Bullets.

Now for a word about sizing cast bullets of any kind. Mould cavities are not perfectly round, except by chance, although they are pretty close to it, and different bullet alloys shrink differently on cooling. In casting bullets, the halves of the mould block are not always pressed together exactly alike, especially when casting rapidly, so it is necessary to make the moulds so they will cast bullets slightly over size, later sizing them to the correct diameter to remove the inequalities in them. This not infrequently results in the removal of more metal from one side of the bullet than from the other. Sometimes one side of the bullet hardly touches the sizing die while the other is sheared off in a way that leads the reloader to believing that the sizing dies are way out of line, whereupon he sets up a loud howl that his bullet sizing contraption is no good. Far be it from me to poke fun at the inexperience of any reloader for while

the mechanics of hand-loading are indeed simple, there are a multitude of little details that cannot be learned in a day. Nevertheless, I am forced to remind the reader that howling is done with the mouth rather than the brain and while sizing dies and loading tools can't always be perfect, they hit a pretty fair average. As this condition of "off-center" sizing of bullets is not uncommon, let's take a careful look at it.

When a bullet is fired, it passes through the barrel revolving around its *center of form* because it is held by the barrel, but when it emerges from the muzzle and is no longer supported, it rotates around the *center of mass.* (Center of gravity). If the center of form or shape and the center of mass or gravity are not the same, the rotation of the bullet will be eccentric. If the eccentricity were the same in all bullets fired, the accuracy would be good in spite of the condition, but this is not likely to be the case. Therefore, one of the problems in making any kind of bullets is to get these two centers to coincide and it is with this object that we size our cast bullets instead of shooting them just as they come from the mould. True, if we do use them as cast, the barrel will do the sizing but it may not do it always the same; one bullet may bear harder on one side than another, etc.

The diagram reproduced below will show why bullets are not necessarily off center because more metal is sheared off one side than the other. The drawing is, of course, grossly exaggerated, but will show the principle clearly. "A" represents the center of mass of the bullet as it comes from the mould and "B" the center of form and we want to get the two to coincide. When the bullet is forced through the sizing die, the side "D" had little or no metal removed from it while the side "C" is sheared off. The bullet appears to have been forced off-center, but actually it is not, and the point "A" has been moved over to "B" approximately. The difference between the two is not often sufficient to affect the accuracy at ranges at which cast bullets are usually fired. It is better, theoretically, if the cast bullet is round to begin with and the removal of metal is equal on all sides, but bullet moulds cannot be made to cast *perfectly* round bullets except by chance or at a prohibitive manufacturing cost. Then there is always shrinkage to contend with. Swaged bullets can be made round and to the correct diameter to begin with and they only have to be sized to remove the small amount of metal that is squeezed out when the grooves are rolled into them, but not cast bullets.



Sizing Diameter. Now, about the diameter to which a bullet should be sized. Most hand books on reloading describe methods of measuring the groove diameters of barrels. They do so for the benefit of the fellow who has a special, obsolete, or other anomalous barrel, but it seems as though about fifty percent of the people who read the directions feel that they must measure their barrels before they can get a bullet mould, overlooking entirely the fact that bullet moulds are standardized articles and are not made specialty for each barrel. The same holds true to a lesser degree with bullet sizing dies. If you have a modern rifle of any reputable make, there is no need of measuring your barrel. I refer particularly to rifles made in the United States. Even with the Krag and Model 1917 rifles, which vary more than an ordinary amount in their bore and groove dimensions, this holds true.

In revolvers, the barrel dimensions are not the sole governing factor in determining the bullet diameter, as the bullet must be large enough to receive some guiding support in the throat of the chamber. For example, ·38 Special Colt Revolvers have a groove diameter of ·354 inch, subject to manufacturing tolerances, but they use bullets measuring ·358 inch in diameter. If a ·354 inch bullet were used, it would receive little or no support in the throat of the chamber and its angular entrance into the barrel would be increased, to say nothing of the evil effects upon the bullet itself from the excessive reduction, of which we will have more later. The standard diameters of revolver bullets have been worked out over a period of time, more by practice than by theory and the novice who sticks to standard bullet diameters is making no mistake. Revolvers, with their separate rotating chambers, present an entirely different problem from rifles and pistols and the two should not be confused.

Somewhere, somehow, the word got noised around that cast bullets for rifles had to be ·003 inch larger than the groove diameter of the barrel they were to be fired in. I don't know where it came from but it is the "bunk" and the worst part of it is that the sad news has penetrated deep into the sanctums where bullet moulds are made. There are two very good reasons for making moulds to cast bullets a few thousandths of an inch over size, other than to true them up by sizing. If the cherries with which these moulds are made are a trifle large, they can be re-sharpened more times which increases their useful life and decreases the tool cost. Also, it permits sizing the bullets a thousandth or so over standard size for the occasional barrel that may run a bit too large for standard diameter bullets. But there is no reason for carrying this too far, as has been done with some bullets.

Thirty caliber bullets, being the size most extensively used, may be taken as an example. The standard groove diameter of caliber ·30 barrels is, and always has been, ·308 inch. Some barrels in commercial production will run as large as ·309 inch and on rare occasions, a little larger. If a ·308 inch bullet is centered in a ·309 inch barrel, only one half thousandth of an inch will be left on opposing sides of the bullet, (ignoring the expansion that takes place when the bullet is fired) an insignificant amount even with hard jacketed bullets. With lead alloy bullets which, at their hardest, are relatively soft and plastic, this difference in diameters is just about nothing. The correct diameter for flat base bullets for caliber ·30 arms is and always has been ·308 inch, which is perfectly natural and obvious. Bullet moulds for such caliber used to be made to cast the bullets about ·311 inch in diameter, although many of the older moulds will drop their bullets closer to ·308 inch. This ·311 diameter allows three thousandths of an inch for variations in the cherrying of the moulds, wear of the cherry and allows plenty of excess metal on the bullet for truing it up in a sizing die. Bullets seldom run more than a thousandth of an inch out of round as they come from the mould, so there is still a couple of thousandths for the reloader to play around with if he wishes or needs an oversize bullet.

Apparently, because bullets of this caliber were often cast as large as ·311 inch, the idea has gotten around that bullets *must* be several thousandths of an inch larger than the standard groove diameter and most of the newer bullets cast large enough to *size down* to ·311 inch, which means that they cast around ·315 inch. These ·311 inch bullets are so large that they make the necks of the cartridges they are loaded in too large to go into the chambers of some commercial rifles. Military chambers are purposely made a trifle large so the arms will surely function with dirty chambers and oversize cartridges, as both of these conditions are found under war time manufacture and service, consequently, ·311 bullets will work in such chambers. When bullets are made so large that they cannot be loaded into standard chambers it certainly looks as if something was wrong, doesn't it? The common remedy for this fault is to size the bullet smaller, which seems simple enough at first glance, but in reality this is a make-shift remedy with certain serious faults. In the first place, if the diameter of the bullet is too large to begin with, the diameter of the ogive or nose is also too large for the throat or bullet seat of the barrel and this part of the bullet is not affected by any sizing operation. It not infrequently happens that, regardless of the sizing, these oversize bullets have to be seated abnormally deep into the cases, in order to get the cartridges into the chamber, but this is not always a serious fault as far as their performance is concerned.

Bullets will size very nicely if the reduction in their size is not much over 1% of the bullet diameter. This means about ·002 inch for caliber ·22 bullets, ·003 for ·30 and ·004 for ·44 and ·45 calibers. These reductions are approximate but if they are exceeded appreciably, the bullets may size irregularly, off center and often the lubrication grooves will be closed up enough to prevent proper lubrication. It is not in the cards to size a bullet that casts ·315 inch in diameter down to ·308 inch, therefore; the groove diameter of the barrel is not the sole determining factor in sizing bullets; the limitations of the bullet itself must be taken into consideration.

There are a few plain base bullets that are designed to be shot as they are cast and without any sizing whatever, although they must be lubricated. These comments on bullet sizing, of course, have no reference or application to such bullets.

Jacketed Bullets.

Most jacketed bullets consist of two parts; the jacket and the core. Both jacket and core are made separately and assembled to make the complete bullet. Numerous materials have been tried or used for making bullet jackets. Some bullets made in Europe have jackets of soft steel, heavily plated with copper. As the copper plating is more or less porous, such bullets are apt to rust under unfavorable climatic conditions. They are also rather hard on barrels.

The two jacketing materials most commonly used in the United States are cupro-nickel and gilding metal. The former is an alloy of copper and nickel as its name indicates, the nickel content being just about sufficient to give it a white or nickel appearance. Cupro-nickel was used almost entirely for bullet jackets up until the end of the World War. It had two serious disadvantages; it was tough stuff and difficult to manufacture and it had a further disadvantage of building up lumpy fouling in rifle barrels, particularly near the muzzle, when the velocity of the bullets exceeded about 2000 f.s. This metal fouling destroyed accuracy and was difficult to remove. If a rifle were fired long enough, the metal fouling would build up about so much and then shoot out, after which it would build up again. Firing a few bullets at very low velocity would usually take it out but the usual method was to eat it out with a special ammonia solution which, if fresh and not left in the barrel too long, would eat or dissolve the cupro-nickel without harming the steel. The safeguarding of the steel depended upon the presence of a sufficient amount of ammonia gas in the solution and if too much of the gas escaped, the solution would cause rapid rusting of the barrel. This made cupro-nickel bullets a nuisance to the shooter and efforts were made to find a remedy for metal fouling.

The copper rotating bands on artillery projectiles also cause metal fouling and the French, who by the way have been responsible for many advances in the field of ballistics, discovered that if tin foil was put into artillery ammunition, metal fouling could be prevented. The tin, vaporized by the heat of the burning powder, coated the bore and either due to its temporary molten state, its anti-friction properties or both, prevented the building up of lumpy fouling.

The duPont Company utilized this idea and brought out their I.M.R. Nos. 15½ and 17½ powders, which had metallic tin incorporated in them. The use of these powders does overcome the lumpy fouling of cupro-nickel bullets, but they leave a coating of tin in the bore that is harder to remove than the nickel fouling. This really is of small consequence, as the presence of the tin does no harm and takes the form of a thin uniform plating throughout the bore. It did raise the devil with the ammunition boys for a while, as these tin incorporated powders are hard to ignite properly and most of the primers in use at the time they first made their appearance wouldn't do the trick. With proper primers they are excellent powders, but the tin idea was just a little bit late. The ammunition companies had also been working on the problem from the angle of bullet jacket material and about the time the “tin” powders came out, gilding metal jackets also made their debut.

Gilding metal is a high brass composed principally of copper with a small amount of zinc added. It is not new, nor is its use confined to the making of bullet jackets. It varies in composition according to its use and has long been used in the manufacture of cheap jewelry, as one alloy has the appearance of gold and does not tarnish easily. The alloy used for bullet jackets is composed of about 90% copper and 10% zinc. At first; gilding metal jackets were coated with a very thin coating of tin which was applied by a mechanical process. This coating was hardly of measurable thickness and served only to prevent oxidation or discoloration of the gilding metal. The practice of coloring gilding metal jackets with tin has been discontinued. Western Lubaloy is very similar to gilding metal except that it contains a small percentage of tin in the alloy, which really makes it a bronze. It is to all intents and purposes the same as gilding metal.

(Note. The ammunition made at Frankford Arsenal for the 1921 National Matches had bullets heavily plated with tin. This ammunition was satisfactory when first loaded. Tin has an affinity for brass and in this ammunition the tin combined with the insides of the case necks, forming a union between the bullet and the case just as though the bullets were soldered in place. This union is so strong that it is impossible to extract the bullets and if the ammunition is fired, dangerous pressures will develop. Most of this lot of ammunition, the only one so loaded, has been shot or destroyed, but anyone running across any of it should destroy it or preserve it only as a curiosity in the development of ammunition. It should under no circumstances be fired. The marking on the case heads is, F. A. 21-R.)

Bullet jackets are drawn in much the same manner as cartridge cases. They may be drawn to their finished shape or in the form of cylindrical cups which are later given the proper form. Great care must be taken to have the jackets of a uniform degree of hardness, they must be of a proper and uniform weight when trimmed to length and the wall thickness must be uniform all around. If too soft for

the cartridge they are made for, the bullets will "slug" excessively when fired. Slugging is a bulging deformation of the bullet that takes place in the barrel when the bullet is too weak to withstand the pressure applied behind it. If the jackets are not of a uniform weight, the finished bullets will also vary in weight and if the wall thickness of the jackets are not uniform, the center of mass of the finished bullets will not coincide with their centers of form. There is no object in going into great detail here on all of the problems of making jacketed bullets, in fact, the only useful purpose to be served by this description is to give the reader some idea of what it is all about so he can appreciate the limitations of the jacketed bullets he buys, and load them to get the best results. Each cartridge presents its own problems of bullet manufacture and suffice to say that the jacket of a bullet that must expand on animal tissue when fired with a muzzle velocity of 1700 f.s. must be made differently than the jacket of another bullet of the same weight and caliber that is to be fired at 3000 f.s. Both bullets may *look* alike but that is probably as far as their similarity will go.

Bullet cores are made of lead alloyed with tin or antimony to give it the proper degree of hardness for the purpose that the bullet is to serve. The cores are swaged to form in the same manner that factory lead bullets are made. As the cores come from the swaging machines, samples are checked for weight, as they must be uniform and of the correct weight if the finished bullets are to be correct. Variations in weight are caused by a lack of uniformity of the percentages of the metals in the alloy. The slugs from which the cores are made may be cast in moulds or cut from wire made of the proper alloy, the latter being the prevalent method today.

To make the lead wire, the metals are alloyed in the proper proportions and are cast in cylindrical ingots. These ingots are put into large hydraulic presses which squeeze the metal through a die of the proper size, extruding it in the form of wire, much in the same manner that tooth paste is squeezed from a tube. Great care is necessary in making the ingots, for when the metal is poured into the ingot mould there is a tendency for the lighter metal in the alloy to rise to the surface, just as it will in a melting pot when casting bullets. This condition will result in one end of the finished wire being of a greater specific gravity than the other. As the shape and volume of the cores is definitely fixed by the dies in which they are formed, the cores from one end of the wire will be much heavier than those from the other end, hence the cores are checked frequently for weight and when they begin to run lighter or heavier than normal, the balance of the wire is discarded.

The slugs come from the swaging machines covered with oil and *all* of this oil must be removed from them before they are assembled into the bullet jackets. The presence of oil between the core and the jacket will result in slippage between when the bullet is fired and good accuracy cannot be obtained with bullets in which this condition exists. There must be a tight assembly between these two components.

And that brings up a point. Some reloaders attempt to alter the diameters of jacketed bullets by swaging or reducing them in hand dies, so that they will better fit some particular rifle. While this can be done, at least with a fair degree of success, there is danger of ruining the bullets in so doing. The jackets are of a resilient material while the cores are not, consequently if the bullet is squeezed down to a smaller diameter, the bullet and the core will be compressed together while in the die but when the bullet comes out, the jacket may spring back slightly, while the core certainly will not. The upsettage that takes place when flat base bullets are fired may off-set this condition, but if it doesn't the accuracy will suffer. Boat-tail bullets do not expand or upset when fired and any attempt to change their diameters by swaging them will destroy their accuracy, especially at the longer ranges.

After the cores are freed of oil they are assembled with the jackets, by being forced into them while the jackets are held in dies. If the bullets are of the military or full jacketed type, the cores are fed into the base ends of the jackets; while for soft point, open point or other expanding bullets having separate tips, they are fed in from the point end. The boat-tail, if any, is then formed and the rear of the jacket based over or the point is formed and the bullets are passed through a sizing die. Cannelures for crimping, or for weakening the jacket to promote expansion, are rolled in after the bullets are completed otherwise. Canneluring jacketed bullets, and especially boat-tail bullets, tightens the assembly of core and jacket and improves their accuracy. Special care is necessary when making boat-tail bullets without cannelures.

Now for a word about expanding bullets. Way back in the days when grog shops were called saloons instead of taverns there was a caliber ·30 rifle called the Krag which tossed a round nose bullet weighing 220 grains with a muzzle velocity of about 2000 f.s. Sporting or hunting bullets for it and other rifles of the same caliber (·30-40) were made with a liberal exposure of lead at the nose of the bullets. These soft point bullets were, at the velocity mentioned, about the best killers of thin skinned game that we have ever had. The soft points mushroomed beautifully, while the high sectional density (length and weight in relation to the area of the cross section) caused them to plow right on deep into the animal after the point had expanded to about twice its original diameter.

But about the same time we were hit with the velocity craze and no rifle or cartridge was any good if it wouldn't shoot as flat as the proverbial pan cake. At increased velocities, the old soft point bullets weren't so good. The noses flattened too quickly and too much, the lead being spread out and separated from the rest of the bullet on impact. This caused bad superficial wounds, while the rest of the bullet with the lead point eliminated often proceeded on its way like a full jacketed bullet, making a deep but small wound lacking in shock effect.

The ammunition boys went to work to make new types of bullets that would not expand so easily and that would stand the higher velocities, and they have been at it ever since—trying to make bullets that, at the velocities at which they are fired, will produce the expansion and deadly effect of the old soft point bullets. Most of these newer bullets have been unsuccessful; they expand too quickly, destroying too much meat in the smaller animals and opening up or even going to pieces before penetrating into the vitals of the larger ones. There are some very good ones among them and in selecting expanding bullets for loading purposes, the handloader should consider the velocity at which he is going to drive the bullets, as well as the kind of game he is going to use them on. Magazine articles recounting the actual experiences of hunters are a better guide to selection than ammunition catalogues. It is but natural that the ammunition manufacturers should extol the virtues of their products and sort of forget about their faults; we all do that, but the real reason for recommending magazine articles in preference to catalogues is that the *only* way that the effect of a bullet on game can be found out is by shooting game with it and that is what the stories tell. Catalogues are inclined to lay emphasis on bullet energy; and frankly, energy expressed in foot pounds doesn't mean a damn thing in a hunting bullet. It is the way that energy is used up on the animal that counts or in other words, the effect actually produced by the bullet.

A large percentage of shooters never hunt or really expect to hunt big game and such hunting as they do is limited to small animals, some of which are very tenacious of life. If the flesh is to be eaten, it is necessary that as little as possible of the meat be destroyed by the bullet. For such purpose, full jacketed bullets are desirable if the average range be long, as these bullets can be driven at higher velocities than cast bullets, but at the shorter ranges cast bullets driven at as *low* a velocity as is practicable are excellent.

In settled communities this introduces a complication, as loads of this type are apt to ricochet or glance. The distance that a bullet will ricochet to, or the direction that it will take after impact with the ground or any hard object, is a matter of uncertainty. The heavier the bullet, the higher its velocity and the less it is deformed on impact, the farther it will go when it glances. Cast bullets will usually deform more on impact than jacketed bullets and the more a bullet deforms, the greater the air resistance will be and consequently, the shorter the ricochet range. In artillery firing over water, the ricochet range is considered as being about two thirds of the actual range, but such firing is done at long ranges only, nearly the effective range of the gun, and is an unsafe rule to apply to small arms. If one is shooting at a hundred yards with an arm that has an effective range of 2000 yards, it would be ridiculous to consider the ricochet range as 67 yards. I have known of Springfield bullets causing complaints from about two miles beyond where the bullets struck, so when shooting solid bullets, or any bullets at low velocities, it is well to be very careful of the direction of fire and to only shoot when there is a good back stop for the bullets.

There is another bad feature of ricochet bullets: If they are deformed much on impact, they make a peculiar whining noise as they go through the air and this sound can often be heard for a considerable distance. I have yet to see an innocent by-stander who has heard a bullet ricochet that wasn't ready to swear by all that is holy that it went right past his ear.

The safest loads to use in a settled community are light weight, open point, jacketed bullets driven at the highest velocity possible with safety. Such loads will almost always cause the bullets to go to pieces on impact; but bullets sometimes behave in a freak manner and very, very rarely one of these light open point bullets will glance. When using them it is still necessary to use care and judgment in shooting, even though the chances of getting a ricochet are remote. These bullets go into such small pieces that the fragments lack the weight or energy to go very far and they offer considerable air resistance in proportion to their size. The trouble with these loads is, that they are ruinous to small game and will practically blow it to pieces. They are excellent for rodents and predatory animals whose meat or fur has no value. What the small game hunter wants is a high velocity load having a flat trajectory, that will kill cleanly without destroying meat, and that will go to pieces on impact with the ground; but it can't be done. Cast bullets, including gas check bullets, cannot be driven at very high velocities nor have they particularly flat trajectories. One can't beat the game by using short, light weight, gas check bullets for such bullets must be driven at lower velocities than the longer ones in order to get good accuracy. They will kill cleanly but they will not break up on impact. Full jacketed bullets can be fired at high velocities and will kill cleanly as a rule, but they will not break up and will ricochet a long way. The heavier, expanding point bullets can be loaded to give flat trajectories, but most of them will open up more or less, even on small game, and destroy meat, if not the entire animal. Their *points* will break up on impact with the ground but the body of the bullet will not. For instance, a 150 grain, cal. ·30 open point bullet will, on impact with the ground, usually have the point disintegrate but the resultant or remaining slug will weigh about 90 grains, and a 90 grain slug can travel a long way and do a lot of damage. The light weight, open point, jacketed bullets can be fired at high velocities and will break up on impact, but they will also break up on and raise the devil with meat. So there you are and take your pick.

There is, of course the question of the hollow point cast bullet but suffice it to say that these cannot be driven fast enough to break up with certainty, although they will usually flatten or partially disintegrate to a greater extent than solid bullets, when fired at the higher velocities.

PART TWO

Ammunition Assembly

CHAPTER FIVE

BULLET ALLOYS.

Lead forms the basis of all cast bullet alloys but lead alone is not well suited for making bullets. In the first place, pure lead does not flow well or fill out properly in a bullet mould and bullets cast of pure lead are apt to have rounded edges. Furthermore, there is a considerable amount of shrinkage when pure lead cools and, if a bullet mould happens to be small enough to cast a bullet of the correct diameter to use without sizing, a bullet of pure lead from this mould will be found to be somewhat under size. In addition, lead is very soft and bullets cast of it are easily damaged in handling, are likely to be scraped or sheared when being seated in the mouths of cartridge cases, and there is a tendency for pure lead to rub off in streaks on the inside of the bore, leading the barrel and rendering it inaccurate. I do not mean to say that lead bullets cannot be used, merely that in general bullets of pure lead are more difficult to cast and are less desirable for use than those cast from an alloy of lead and other metals. The metals most commonly used with lead for making bullet alloys are tin and antimony, either or both being used at times.

Tin. Tin is a convenient metal to use in making bullet alloys because of its low freezing point. Tin possesses certain anti-friction properties that slightly reduce the probability of leading, although care must be taken in using the tin so as to avoid excess in the alloy. As an example of the anti-friction properties of tin, which is commonly used in bearing metals because of this quality, brass (copper and zinc) is almost worthless for bearings; but bronze, (copper and tin) make excellent bearings. The same is true of Babbit metals, as those containing tin are used in high-speed bearings while the so-called lead Babbit can only be used in low speed bearings. The addition of tin to lead hardens the mixture and its hardness will increase as the percentage of tin increases. Lead and tin will form a true alloy, that is, they will mix together when the metal is in a molten state and remain mixed after the metal solidifies. This is known as a solid solution, but lead will only retain about 11% of tin in solid solution. If more than 11% of tin is used the excess tin will crystallize out in the form of pure tin crystals when the metal cools. These crystals will be more or less evenly distributed throughout the alloy. About 10% of tin, or roughly, a mixture of 1 part tin to 10 parts lead is about the hardest lead -tin alloy that it is practicable to use for bullets; and this mixture is unnecessarily hard for most purposes. This 1 to 10 alloy of tin and lead has a further objection in that its melting point is rather low.

The reader should not get the idea that tin, because of its antifriction properties, is a panacea for leading. It is not. I believe, from long and careful observation, that a little tin, judiciously used, will reduce the chances of leading in most arms. On the other hand, I know that too much tin may actually cause leading. Tin and lead form solder and while an alloy containing only 10% of tin is hardly comparable with commercial solders, particles of such an alloy will sometimes melt under the heat of powder gasses and adhere firmly to the bore. This is especially true of revolvers, for reasons to be pointed out later.

Antimony. Antimony makes an excellent hardening agent for bullet alloys, it is used almost entirely as a hardening agent for lead bullets as produced by the ammunition companies and, despite the fact that antimony does not have the anti-friction properties of tin, it is nevertheless an excellent hardening agent for bullets when used alone. Antimony will not form a true alloy with lead. The two metals will only remain in solution as long as the alloy is in a molten state; when it cools, the antimony will separate out in the form of antimony crystals distributed throughout the mass of lead, but this is not prejudicial to the casting of good bullets.

Antimony has a certain advantage over tin for alloying bullets in that it is cheaper and need only be used in small percentages and that it will make harder bullets and bullets with a higher melting point than those made from an alloy of tin and lead. The principal objection to its use is its relatively high freezing point (or melting point) which is roughly double that of lead. The presence of antimony in the bullet alloy makes the metal free flowing and permits it to fill out the mould cavity more completely than alloys not containing antimony, as there is a tendency for antimony alloys to expand slightly on cooling rather than to shrink.

Copper. Copper is of little use in bullet alloys. Years ago, the Ideal Manufacturing Company of New Haven used to sell a bullet alloy containing copper, they recommended it for use in making gas-check or other bullets which were to be driven at a relatively high velocity; but the fact of the matter is that copper will not alloy with lead and if copper is used in a bullet alloy it will only take the form of more or less irregularly divided particles usually distributed unevenly throughout the mass of lead. These particles of copper will not melt at temperatures which can be obtained on the kitchen range and the fact that the use of this metal has long since been discontinued is sufficient evidence of its faults.

Mercury. Mercury has at times been suggested as a hardening agent for bullets but I cannot urge the reader too strongly to keep away from any attempt to use mercury for this purpose. Properly used, a very small percentage of mercury will harden lead.

But mercury in the bullet will attack the brass of the neck of the cartridge case and, furthermore, *mercury under no circumstances should be applied to molten bullet metal* as it will immediately vaporize and the mercury vapor, if inhaled, will prove fatal. There is no remedy for it once it is inhaled. There is a method of gilding brass articles by applying a soft amalgam of gold and mercury to the brass after which the latter is heated and the mercury expelled; but in plants where this is done, extraordinary methods are employed, not only to recover and condense the mercury vapor but also to carry off any fumes from it. Where the apparatus is defective or the ventilation insufficient, many deaths have been known to result.

Arsenic. Arsenic is also good for hardening lead, from 1½ to 2% giving a satisfactory degree of hardness for all ordinary purposes. The melting point of arsenic varies and is usually higher than that of antimony, although the sublimed product melts at a lower temperature.

This metal is poisonous and begins to volatilize at 100° C, the volatilization increasing with the temperature. Just what effect the vapors produce on the respiratory system I don't know, but they are probably injurious.

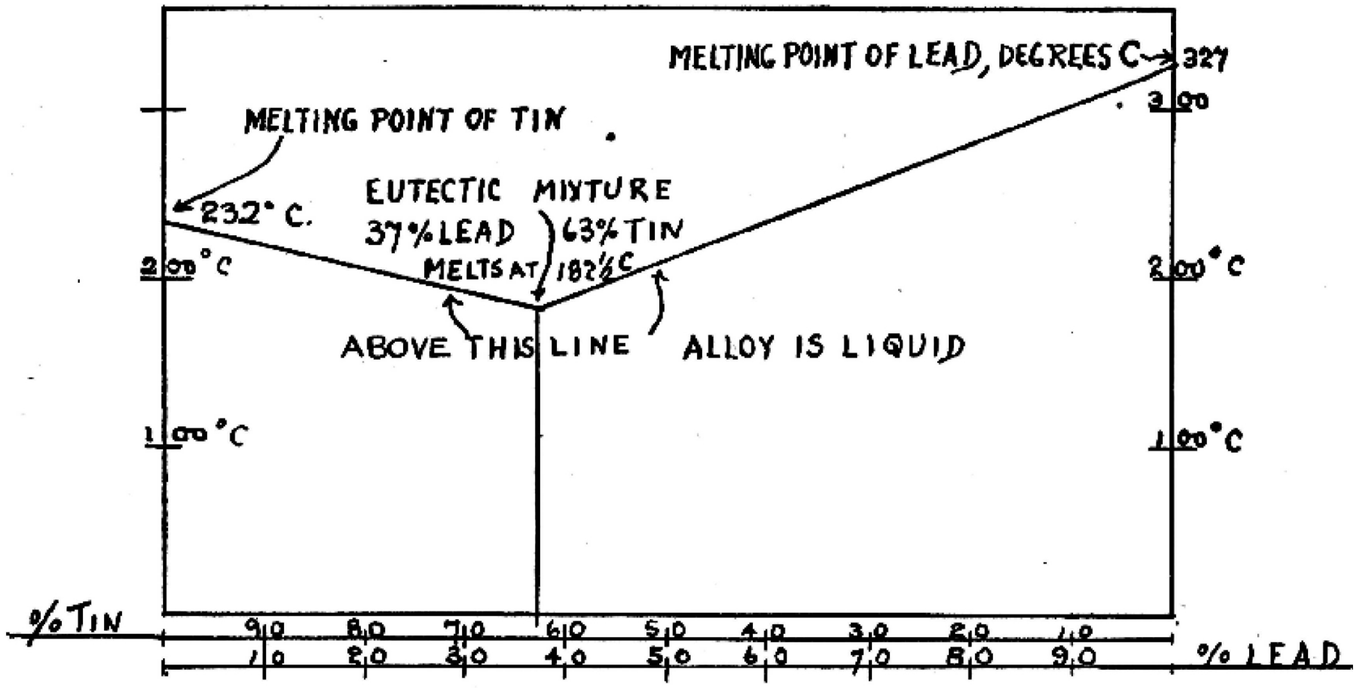
Both mercury and arsenic have their proper uses in the field of metallurgy but are best left in the hands of those who have the knowledge and facilities to use them properly. Antimony and tin are available almost anywhere, they are satisfactory hardening agents, are safe and convenient to use, and the reader should depend upon them entirely.

Melting Points.

In casting bullets, particularly bullets that are to be driven at high velocities, the hardness of the bullet is usually the only thing which is taken into consideration but it is well also to bear in mind that the melting points of different alloys are also of importance. The burning temperatures of powder charges, even those developing low pressures, are greatly in excess of the temperatures necessary to melt any lead alloy bullets, the only reason the bullets do not melt is because of the short period of time the bullet is subjected to this intense heat. While the difference between the melting points of different lead alloys is insignificant in comparison with the high burning temperatures of powder charges, nevertheless a difference of a few degrees in melting temperature may make the difference between a bullet that is accurate and performs satisfactorily, and one which leads the barrel and is inaccurate.

To better understand how the melting temperature of bullet alloys is affected by the alloy, there are quite a number of metals whose melting points (or freezing points) are lowered when other metals are alloyed with them. The terms "freezing point" and "melting point" really mean about the same thing. The freezing point of water is zero at which point ice is formed. If the temperature rises at all above this point the ice will melt; this condition holds true of metals and the temperature at which metals *solidify* is called the freezing point. Obviously their melting point is at about the same place, so for practical purposes the two terms are interchangeable.

Lead has a melting point of 327·4º C. while tin has a melting point of 232·0º C. But if a small amount of lead is added to a mass of tin, the melting point of the alloy will be lowered below that of the tin: likewise if a small amount of tin is added to a mass of lead, the melting point will be lowered below the melting point of pure lead. Now if we consider the melting point of lead as a point on the side of a square and the melting point of tin as another point on the opposite side of the square, at the proper relative height from the base of the square, and we continue to add lead to the tin side and tin to the lead side, the melting points of the alloys thus formed continue to drop until the two curves formed by the points will meet. This point of junction is known as the "eutectic point." The alloy corresponding to the composition at which the two lines meet is called the "eutectic alloy" and the temperature is the "eutectic temperature" The eutectic alloy is, therefore, the lowest melting alloy in a series.



Perhaps a simpler way of explaining this would be to say that, as tin is added to the lead, the melting temperature i.e., the lowest temperature at which both metals are completely melted, drops until the eutectic point is reached after which the melting temperature rises, as more tin is added. When the other end of the curve is reached the lead will have decreased to nothing and the tin increased to 100%, so the melting point will be that of pure tin.

The eutectic alloy of lead and tin is a composition of approximately 63% tin and 37% lead, the melting point of this alloy is approximately 182½° C. The melting point of an alloy composed of 90% lead and 10% tin, which is about the hardest that can be used satisfactorily for bullets, is roughly 228° C. I do not know the exact figures off hand but those given are approximately correct.

The same condition exists with alloys of lead and antimony. If a curve is plotted in the same way with these metals and the freezing points of different alloys measured, the freezing points on the antimony sick will become lower as lead is added and on the lead side the temperature will be lowered as antimony is added until the two lines meet. But in this case the eutectic alloy is composed of about 87% lead and 13% antimony and the eutectic point is about 240º C.

In making antimony alloys it is only necessary to use about 5% antimony to 90% of lead to get good hard bullets and such an alloy will have a melting point—or the point at which both the lead and the antimony are completely melted and in solution—of approximately 300° C, and with a smaller percentage of antimony the melting temperature will be very close to that of pure lead. From this it will be seen that antimony alloy bullets have an appreciably higher melting temperature than those made from lead and tin.

Alloys of two metals are known as binary alloys but if lead, tin and antimony were used together in a bullet alloy—which can be done advantageously—the alloy would become a ternary alloy and the status of such alloys are so involved that no attempt can be made to give any specific figures or melting points for different combinations.

When an alloy of two or more metals is used at too tow a temperature it may be sluggish in action and have a slushy appearance; and it is for this reason that coal ranges and gas or gasoline stoves have been suggested as better than electrical melting units for casting bullets, although some of the latter do work satisfactorily if the volume of metal is not too large.

Oxidation and Specific Gravity.

Lead oxidizes readily in the presence of air, taking up oxygen from the atmosphere, which, in the molten state, forms lead monoxide. This makes its appearance first in the form of a scum on the surface of the metal, the scum gradually darkening and finally turning into a brown powder which floats on the surface. The hotter the metal becomes, the more rapidly this oxide forms.

In its solid state, lead tarnishes rapidly. While the coating forms speedily, it does not increase in thickness much, even though the lead is exposed to the air for a long period of time. Old bullets will often have a hard, dark grey coating on them, but if this coating is cut through it will be found to be very thin. It is of little consequence and is only mentioned as an example of the oxidizing properties of the metal. The presence of even as small an amount as 1% of antimony greatly reduces the corrosion of lead. Incidentally, an alloy of from 1% to 1½% of antimony and the balance lead makes a very good bullet alloy and is about that used in factory revolver bullets.

Tin does not oxidize readily, either in the molten or solid state, and its presence in bullet alloys also helps to reduce the oxidation of the lead. While it volatilizes slowly at red heat, it does not do so at temperatures at which bullet alloys are ordinarily used.

The three metals just referred to are all of different specific gravities. Lead is by far the heaviest of the three, tin comes next and antimony is a little lighter than tin, volume for volume. If tin, antimony or both of them are added to molten lead and melted in it, an alloy is formed and all of the metals may be thoroughly mixed together. But if the molten alloy is allowed to stand, the lighter metals will tend to rise toward the surface, leaving the alloy rich in lead at the bottom and rich in lighter metals at the top. If the melt is allowed to cool and the resultant block of metal is sawed through the center, polished and etched, examination will show the bottom of the pot to contain some antimony crystals surrounded by lead-tin eutectic. Toward the top the antimony crystals will increase in

density and possibly tin crystals will appear (if the alloy has stood long enough for a sufficient amount of tin to rise to the surface) separated by eutectic.

Therefore, to get bullets of a uniform alloy and consequently of a uniform density and weight, it is necessary to keep the molten alloy well stirred.

Preparing Bullet Alloys.

Lead-tin alloys are the easiest to make, because of the low melting points of these two metals. It is only necessary to weigh out the proportions of each metal desired, melt the lead and then add the tin, which will melt immediately. The alloy should then be fluxed and stirred thoroughly before using.

The preparation of antimony alloys is a little more difficult and requires a *hot* fire, because of the high melting point of the antimony. The proportions of lead and antimony should be weighed out and the antimony broken up as finely as possible by pounding and pulverizing it with a hammer. Melt the lead and bring it almost to a red heat, then add the antimony which will float on top of the lead. The entire surface of the pot should then be covered with powdered charcoal and the heat increased to a point that will bring the lead to a red heat. Stir the metal occasionally, being sure to keep the top covered with the charcoal, for if the lead is exposed to the air when heated to such a high temperature it will oxidize very rapidly. When the antimony is all melted, let the metal cool down, skim off the charcoal and flux the alloy thoroughly before attempting to use it. If tin is to be added to the antimony alloy, it should be put in after the alloy has cooled down considerably. Once the antimony alloy has been made it can be re-melted easily.

Fluxing.

Fluxing serves a double purpose: It makes the metal flow more freely and also removes impurities from it, Salammoniac hydrocarbons in the form of waxes and fats, and rosin are all useful for this purpose. The most convenient for the handloader is probably bullet lubricant, bees wax or tallow, any of which work equally well. When a scum begins to form on the surface of the metal, the heat should be increased, some fluxing material should be dropped into the pot and the melt stirred thoroughly. The smoke given off from wax or grease can be ignited and greatly reduced. I don't profess to know much about the chemical effect of fluxes, but in the case of hydrocarbons a considerable part probably turns to carbon which, in turn, absorbs oxidizing gasses in the metal at the same time causing the molecules to slide more freely on one another thus promoting the fluidity of the melt. Anyway, whatever the cause, the result is to cause the scum to disappear, the oxides to rise to the surface in the form of a dark powder and the metal to flow more freely. The oxides can be skimmed off, leaving the metal bright and clean.

An alloy should never be skimmed without first fluxing, as otherwise some of the richest part of the alloying metals will be taken away.

Temperature of Alloy.

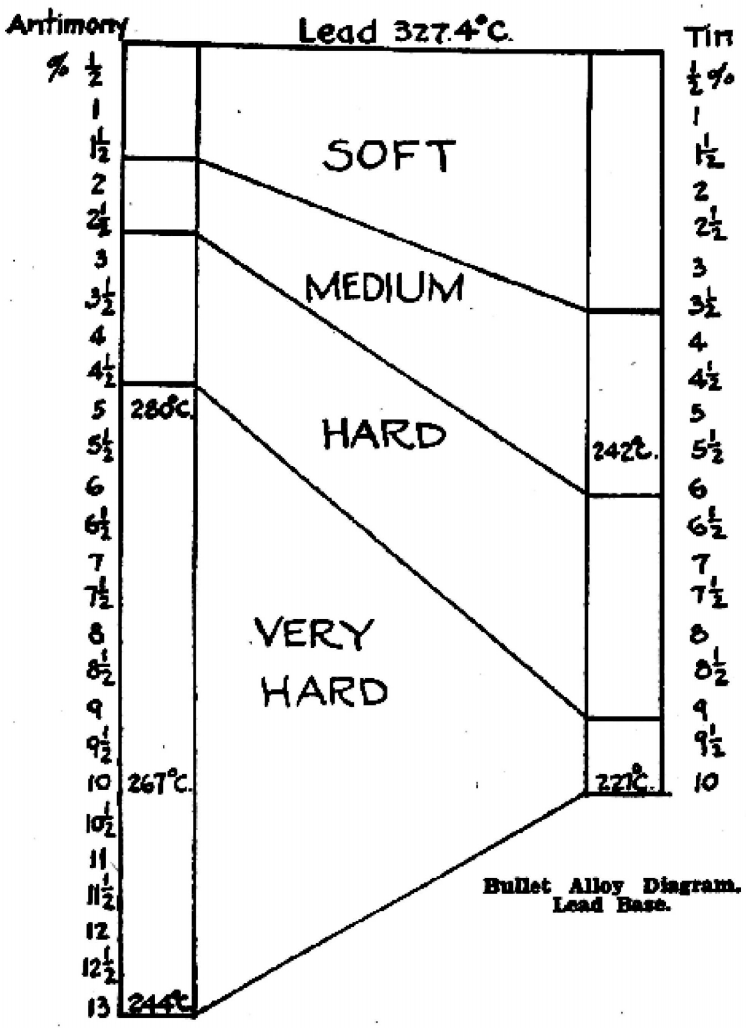
Watch the heat. As has already been, stated, antimony will only form a true alloy with lead when it is melted and as the metal cools the antimony crystallizes out. Tin will form a true alloy if the tin does not exceed 11%. If any antimony alloy is used at too low a temperature the antimony crystals will start to form and float on the top of the melt in the form of a sludge. The same condition can occur with a lead-tin alloy, in which case the lead crystals begin to form first, No amount of fluxing will overcome this, as it is the temperature which is at fault.

Always keep in mind that the stirring incident to fluxing metal cools the melt, so use a source of heat which will be more than adequate for the alloy you are using. Also remember that it is not alone the quantities of metals that you put into the pot which counts *but where those metals are after they are in there* and they must be kept thoroughly mixed in order to get the most uniform bullets.

Suggestions for Beginners.

An alloy of 1 part tin to 20 parts of lead makes a good mixture for all around use with plain base bullets for rifles, pistols or revolvers. For gas-check bullets in mid range loads (the heaviest loads than can be used behind such bullets), use 1 part of tin to 10 parts of lead. A better alloy for this purpose is one made from 1 part of tin, 1 part of antimony, and 20 parts of lead. This is the same as Number 2 Ideal bullet metal which is composed of 90% lead, 5% tin and 5% antimony and which is used extensively for gas-check bullets. This makes an alloy, suitable for almost any kind of bullet and one which is fairly hard. Generally speaking, fairly soft bullets can be used satisfactorily in revolvers but with heavier loads Number 2 Ideal metal bullets should be used in such arms, as there is less tendency for the hard bullets to upset and to expand between the cylinder and the barrel. It is not necessary to be too fussy about alloys for revolver bullets as a bullet made from almost any alloy within reason will shoot well in a revolver if the bullets are properly lubricated. This is also true for bullets for automatic pistols, although the harder alloys are usually preferred for this purpose.

For rifles, moderately soft bullets are quite satisfactory for black powders and low velocity smokeless loads, but if the velocities are increased the bullet mixture should be hardened.



The above diagram is intended to give only an approximate comparison of the hardnesses of lead-tin and lead-antimony alloys. The addition of tin to alloys on the antimony side will probably throw the alloy into the next higher hardness group. The same is true of antimony added to the lead-tin groups.

Bear in mind that such terms as soft, medium and hard are purely relative. There is no sharp line of demarcation between them and just at what point an alloy ceases to be "soft" and becomes "medium" is purely a matter of personal opinion. The melting points given are approximate.

Some rifles are quite temperamental. If your bullets are properly cast, lubricated, and loaded but do not give accuracy, try softening the alloy by adding a little lead to the mixture and see if the accuracy improves. Should the softer bullets make worse groups, harden the alloy and try again. Experimenting in this way will enable you to find the alloy that is best for *your* particular rifle. Before changing the alloy, make sure that your barrel is not leading. If it is, clean the lead out with a brass wire brush, or with metallic mercury and then read the chapter on bullet lubricants before proceeding further.

This little chapter being for beginners I have decided to disclose a deep, dark secret. All this stuff about bullet alloys, melting points and the characteristics of different metals, etc., is apt to be very confusing to a beginner and create the impression that casting bullets is a rather tricky problem. As a matter of fact it is nothing of the kind and to help set the reader's mind at ease on this point, I will disclose, for the first time, and in the strictest of confidence, just what I use myself for casting bullets for ordinary shooting purposes.

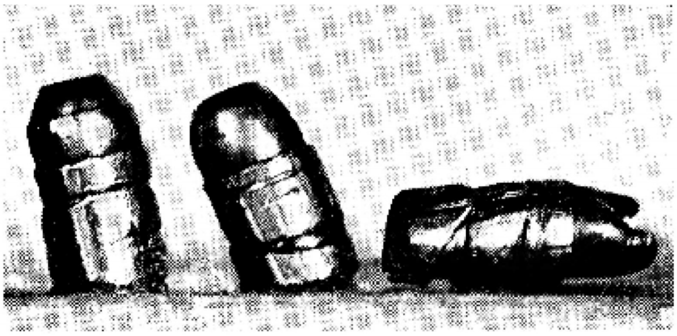
I have a lead pot which I usually keep at least half full of bullet metal. What it is composed of, the Lord alone knows. If I want to cast some moderately soft pullets, I stick my thumb nail into what is in the pot (y'understand Brother, this is before it is melted) and if it doesn't indent easily enough to suit me I heave some lead in. On the other hand, if it is too soft for what I want, I chuck in some antimony alloy, or a little tin, or any odds and ends that are lying around which I think will bring it up to the proper hardness. Following this procedure the alloy is ever changing and is ever of unknown quality. However, the bullets usually seem to go where the gun is aimed when it goes off and I don't get any leading, so it will be seen that the preparation of bullet alloys need not be complicated nor highly scientific.

Occasionally, this conglomeration of metals doesn't give quite the accuracy that I think I ought to get from a particular arm, so then I go into the careful preparation of some new bullet alloys.

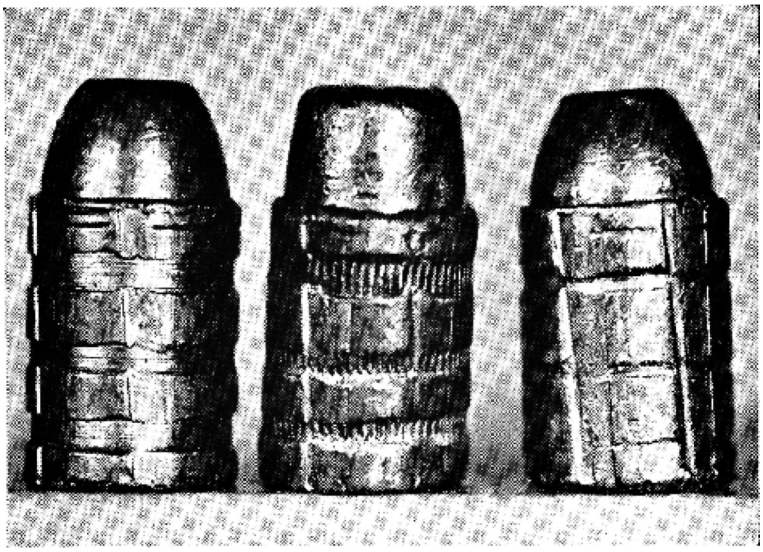
The objection to using an unknown alloy of this kind is limited to the inability to reproduce it if it proves to be particularly good in some arm. I do not believe it is necessary for a handloader to keep a mass of complicated records on bullet alloys. The average shooter probably does not reload ammunition for more than three or four different arms and can easily remember what he uses for bullets in each one. In experimental work it is, of course, necessary to keep records in great detail, but these folks who reload ammunition for inexpensive shooting and for all ordinary purposes do not experiment to any extent which requires this. Once they have an alloy that is satisfactory (which is usually the first batch they mix up) they stick to it and their troubles with alloying bullet metals are over with.

Commercial Metals and Alloys.

Many handloaders are situated in localities where they cannot buy tin or antimony easily, and they may wish to use scrap lead or commercial alloys of lead. When one reads of bullet alloys made of definite proportions of metals, the idea is sometimes created that it is necessary to be very precise about one's alloys. This is true in the case of an occasional rifle that may happen to be cantankerous. In general, any alloy that can be cast into bullets which shoot accurately is a good bullet alloy, even if it has cheese in it. But, in order that one may have some idea of what he is using, the following composition of common commercial alloys are given. These alloys are apt to vary, but the data given is a good average.

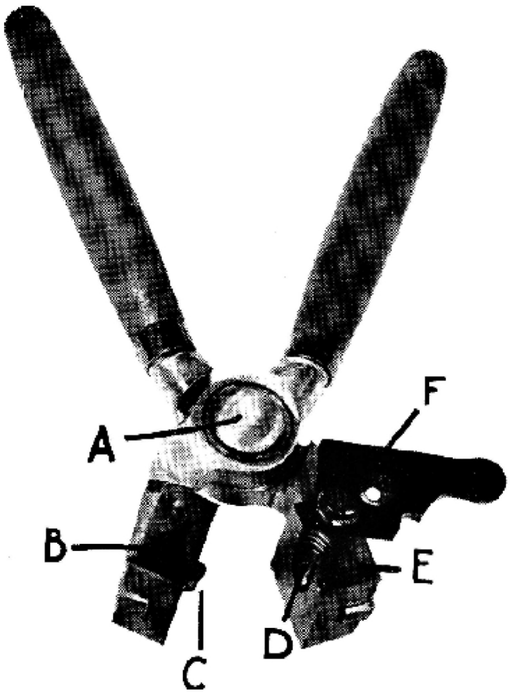


Hollow base bullets in which the cavity was carried too deep. When fired, the bullet slugged badly or the base blew out and the sides collapsed.

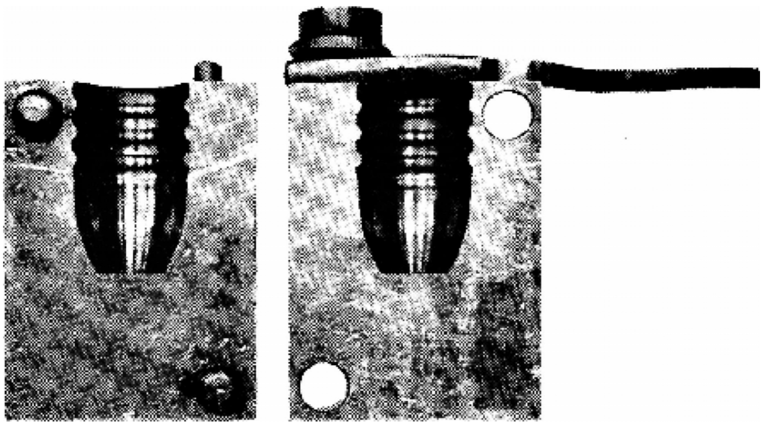


The difference between well and poorly designed lubrication grooves and properly sized bullets is not always apparent until after the bullet has been fired. The bullet on the right has its grooves practically closed up.

PLATE XIII.



Modern Bullet Mould.
A—Hinge. B—Block half. C—Alignment dowel pin. D—Cavity. E—Top surface of mould blocks. F—Swinging gate, with sprue cutter.



Illustrating mould which cast imperfect bullets and which has been "vented" to remedy the defect.

PLATE XIV.

Pig Lead. Name given to commercially pure lead. About 99·6% lead, Melting point, 327·4° C. (621° F.)

Block Tin. Practically pure tin. The impurities are negligible from a bullet casting standpoint. Melting point, 231·9º C. (447·8° *F.)*

Antimony. Contains traces of other metals, but is essentially pure antimony. Melting point, 630·5° C. (1167° F.). Compare the melting point of antimony with those of lead and tin and you will see why this is a difficult metal to work with over the kitchen stove.

Block Lead. As sold by plumbing shops, this may contain anything. It is scrap, melted up. Try indenting it with the thumb nail; if soft, harden as desired. If it is fairly hard, try it as it is. It is better to get pig or pure commercial lead, if available.

Lead Pipe. This is made of commercially pure lead.

Cable Sheathing. Practically the same as lead pipe.

Storage Battery Plates and Grids. 9% to 11% antimony, balance lead.

Storage Battery Connectors. These are softer than the plates and grids. About 3% antimony and the balance lead. Make a very good alloy for all-around use.

Type Metal. About 82% lead, 3% tin and 15% antimony.

Linotype Metal. Composed of 4% Tin, 11 to 11½% antimony and the balance lead. Melts at approximately 450° F. Brinell hardness 19·0 at 20° C. This alloy is all right just as it is for very hard bullets. As it is used extensively by newspapers, it can be obtained almost anywhere newspapers are printed.

Monotype Metal 8 to 9% tin, 17½ to 19½% antimony, balance lead. Brinell hardness 22·5 to 23·0 at 20° C. Melting point about 460º F. While this alloy is unnecessarily hard for bullets, it can be used just as it is. It is not used as commonly as linotype metal.

Wiped Joints. When sawed from the pipe and melted, will be from 10% to 15% tin and the balance lead.

Babbit Metal. Varies a great deal. That for heavy duty bearings runs around 83% tin, 11% antimony, and 6% copper. For low speed bearings, lead is substituted for the tin. The copper will never melt, but will be suspended irregularly through the mass as minute particles.

Plumbers' Solder. Used for wiped joints. 67% lead and 33% tin.

Cal. ·22 Bullets. Mostly of lead, but recently a lot of hard bullets have been put on the market. Antimony is used mostly for hardening them. Treat in the same way as block lead.

The reader should bear in mind that practically all of the commercial alloys in common use vary considerably in their composition and the best that can be done in such a brief space it to give a composite of information obtained from reliable source. While these miscellaneous alloys can be used and doctored up for making bullets, it is far better to use alloys of known ingredients so that they can be duplicated at any time.

CHAPTER SIX

THE CASTING OF BULLETS.

If all bullet moulds were the pink of perfection and *if* all bullet alloys flowed smoothly and alike and were the same temperature, the casting of bullets would be a very simple matter. It would only be necessary to melt the bullet metal, pour it into the mould and dump out a perfect bullet. While bullet moulds, as they come from the manufacturer today, cannot be considered as faulty and are very well made, each mould manufactured has its peculiarities and individualities. Different alloys of bullet metals do not all flow alike and cannot be used at a uniform temperature. Therefore, there is a little trick to casting good bullets that can only be learned by experience. While it will be possible to set down here certain principles, no amount of copy or directions can ever take the place of a few hours' actual experience in casting bullets.

The materials necessary for casting good bullets are: a bullet mould; a dipper or ladle, preferably one made especially for the purpose as supplied by many of the reloading tool manufacturers and having a tubular spout, and a melting pot. A stout stick of wood about ten or twelve inches long is necessary for striking the sprue cutter; some wax or salammoniac for fluxing the bullet metal; a soft pad to drop the bullets on; an old box for the dross or oxidized metal that must be skimmed from the pot from time to time; and a source of heat for melting the bullet metal.

Source of Heat. The old-fashioned kitchen stove is sometimes criticized because of inability to control the heat accurately but this criticism is not justified because it is possible to control the heat of a coal fire by opening the drafts to increase the heat, or by checking the fire, or even by tipping the stove lids to decrease the heat and once the proper temperature of metal is obtained the even heat of a coal fire is very satisfactory. Of course, a gas or gasoline stove is more readily controlled and a little more convenient but is not a necessity.

Electric heating units are not as desirable as a gas flame as a general rule, for sometimes in casting bullets and in the preparation of metals and bullet alloys, an excessive amount of heat is necessary and electrical units are usually a little deficient in the heat that they produce. The ordinary electric stove is worthless, because the pot must set on top of the heating element so that only the bottom of the pot is heated while the greater area of the sides is cooled by the circulation of air. The small electrical bullet casting units are satisfactory in general but are not adequate for preparing bullet alloys and when they are used the bullet metal should be mixed and prepared over a hotter fire and then cast into small blocks of a convenient size for use in these small elements. A suitable mould for the purpose can be made from a square box filled with damp sand pressed down firmly and with depressions made in the sand with the end of a broom handle. It should be borne in mind, however, that none of these electrical bullet casters have sufficient clearance beneath them to accommodate the conventional type of hollow-point bullet mould although they work quite nicely with all other types.

The principal objection to these electric bullet casters is that the metal is always drawn from the bottom of the pot. They are all made in the form of a small ladle or pot with a spout in the bottom. This little pot is surrounded by an electric heating element and is raised up on a support so that the mould can be inserted beneath them with the pouring hole placed against the end of the spout. The spout is closed by a plunger passing down through the metal and the plunger is raised by means of a lever to permit the molten metal to flow out into the mould. To keep the alloy uniform, the metal must be fluxed and stirred frequently and with such a small amount of metal this cools the melt considerably. If the metal is not stirred frequently the lighter metals will rise towards the surface and a lead-rich mixture will be drawn from the bottom of the pot. They are, however, mostly satisfactory and are very handy for casting bullets, but like every other piece of reloading equipment they must be used with due consideration to the results that are to be accomplished.

The ordinary melting pots and pouring ladles, while perhaps less convenient, will nevertheless, be best to use providing the source of heat is adequate, but here again they must be used properly. The larger volume of metal in the conventional melting pot can be kept at a more uniform temperature than in the diminutive electrical units and can be fluxed frequently without reducing the temperature of the melt below a satisfactory working point. But any advantage of the old fashioned lead pot is offset if the reloader continually dips metal from the surface of the pot, as is so often the case. Go to the bottom of your pot to fill your ladle as the movement of the ladle through the melt will help materially in keeping the metals thoroughly mixed.

Melting Pots. The lead pot should hold at least five pounds of bullet metal and preferably ten, as where the volume of metal is large a more uniform temperature can be maintained. This also permits the addition of new metal from time to time, without lowering the temperature of the metal below a set working point. Suitable lead pots can be obtained from any of the reloading tool manufacturers at small expense, while larger ones may be obtained from any plumbing supply house.

Pad for Hot Bullets. A pad must be provided on which to drop the bullets from the mould. The hot bullets are quite soft and are easily damaged and must not be allowed to strike a hard surface or to strike against each other. A piece of old blanket folded a few times is excellent but if a good blanket is used it should be covered with an old piece of cloth to prevent soil and scorch. If you have a work shop or are situated so that you can have a few extra gadgets around without getting too many blessings from the family, a good

bullet catcher can be made by stretching a piece of canton flannel, or any other soft cloth of good strength, across the top of a wooden box and tacking it in place around the edges. Bullets dropped on this will roll toward the center gently and when the accumulation of bullets becomes too heavy they can be removed carefully with a tablespoon.

Flux. Any kind of wax suitable for making bullet lubricant, powdered sal ammoniac or rosin make good materials for fluxing bullet metal. The waxes have a slight advantage in that the smoke produced can be ignited and burned; but you must resign yourself to some more or less unpleasant odors if you intend to cast your own bullets. Bullet alloys are mixtures of lead and tin, lead and antimony, or all three of these metals. As the lead is the heavier of the three there is a tendency for the lighter metal to rise to the surface of the pot. The heat will also cause the metals to oxidize on the surface and these oxides form a scum on top of the metal that must be removed from time to time. The tin and antimony serve as hardening agents and they must not be skimmed off as this will change the hardness of the bullets. Fluxing the alloy will release the metals and leave the oxides in the form of black powder floating on top of the pot, which can be easily skimmed off with a bullet ladle leaving the alloy clean and bright. Experience will show the proper amount of fluxing material to use but the pot should never be skimmed without first fluxing the metal.

To do this, drop a piece of wax or a small amount of rosin or sal ammoniac into the pot and stir the metal rapidly. If wax is used, the gasses given off may ignite from the heat of the metal or can usually be ignited with a match, thus decreasing the amount of smoke and annoyance. The stirring will have a tendency to cool the mixture slightly and where the nature of the mould requires the use of a very hot bullet metal it is well to increase the flame under the pot, where this is possible, when fluxing.

It is desirable to have a tin box at hand in which to drop the dross or oxides skimmed off but, as a matter of fact, any small box of wood or tin will serve.

Bullet Casting Procedure.

Now that we have all the materials at hand they should be arranged conveniently and the pot containing the bullet metal put over the fire to melt. If gas is used it should be turned up full till the metal is completely melted, after which the heat can be reduced as desired. The mould may be rested on the stove or placed close to the flame so as to heat up the block, but should not be allowed to get hot enough to burn any oil or grease that may be in the cavity.

When the metal is melted, put the ladle into it and allow it to heat. Then dip up some metal in the ladle, place the spout in a horizontal position against the pouring hole in the sprue cutter and turn both mould and dipper to a vertical position. Hold them in this position for a second or two. Remove the ladle, leaving some metal in the sprue hole. When the mould and metal are at the right temperature it will require a second or two for this excess metal to solidify but when first starting, the metal may solidify almost instantly due to the mould being too cold. The first bullets are apt to be misshapen affairs for the same reason. If the bullet metal is not hot enough it will solidify before completely filling the mould cavity. On the other hand, if the mould is too cold it will chill the metal before it has time to fill the cavity. When the mould and bullet metal are at the proper temperature it will require a second or two for the excess metal in the sprue hole to solidify after the ladle is removed. When the mould and metal are at such a temperature and the bullets do not fill out completely, it is usually due to mould blocks that fit too tightly together and do not permit the air to escape from some part of the cavity.

When the sprue has solidified the sprue cutter should be struck squarely with the stick and swung to one side, after which the mould may be opened over the pad, allowing the bullet to drop out. If the bullet does not drop out of its own accord, rap the side of the mould joint slightly with the stick of wood to jar the bullet out. *Never stride a mould with a hammer or other metal object.*

If the first bullets are not perfect, continue to cast them; they will get better and better as the mould warms up and you will shortly get perfect ones. As long as any oil or grease remains in the mould cavity the bullets will not fill up or they will be covered with small pits from the tiny gas bubbles formed when the hot metal comes into contact with the oil.

Breaking in a New Mould,

Most mould blocks are made of malleable or alloy iron and come already blued or oxidized, so require no breaking in. If a mould cavity is bright it will not cast good bullets until the surface of the metal becomes oxidized. The ordinary procedure in such a case is to use the mould until the heat transmitted by the bullet metal accomplishes the desired result. This is often a long and tedious process and the job can be greatly hastened by placing the mould blocks on the top of a hot stove or by holding them near a gas flame until the cavity turns to a dark straw or blue. Before attempting to blue a mould cavity the mould should be washed in gasoline or carbon tetrachloride to remove all the oil, as the slushing oil used as a protection against rusting may carbonize and burn onto the mould. This will make blotchy bullets but the offending carbon can usually be removed by rubbing with a soft cloth over the end of a wooden stick. It is a good plan to wash out any new mould, or any mould that has been oiled, before attempting to cast bullets with it. But if gasoline is used it should be outside of any room where there is an open flame. Gasoline is far more dangerous stuff than any kind of powder and the fumes carried to a flame by air currents have been responsible for many bad fires and fatal explosions.

Block Alignment. Contrary to popular belief a bullet mould is a precision implement and it must be used with reasonable care if it is to give long and satisfactory service. We all like to cast bullets with as much dispatch as possible but a little care in opening and closing the mould will not slow up the casting of good bullets to any appreciable extent and it will prolong the life of the bullet mould.

Most of the bullet moulds made today are of the so-called loose block type. The essential parts of one of these moulds are shown in the illustration on Plate XIV. Each half of the mould block contains half of the mould cavity. This cavity is cut with a special reamer called a cherry which is made the exact shape of the bullet and no change can be made in the shape of the standard bullets, for which the manufacturers cut moulds, without making a new cherry which is an expensive job. However, some manufacturers will cut moulds for bullets that are longer or shorter than the standard, where the design of the cherry will permit.

The fit of the dowel pins on one block into the holes in the other block governs the alignment of the two halves of the cavity. When used properly there is very little wear on the holes or the pins but if the mould is yanked open and slammed shut, the holes will become burred at the edges and enlarged, which will throw the two halves of the block out of alignment and make it impossible to get perfect bullets from the mould. This looseness in the two halves of the block is known as “shuck” and can usually only be eliminated by returning the mould to the factory, having the holes reamed out larger and new dowel pins fitted.

Sprue Cutter Adjustment. The "sprue" cutter is a flat steel plate attached to the top of the mould block by a screw. The under surface of this plate fits closely against the flat top surface of the mould and forms the flat base of the bullet. The sprue cutter has a beveled hole in it, the bevel coming to a knife edge at the underside of the plate. This hole is the orifice through which the molten metal is poured into the mould and it is positioned approximately over the center of the cavity by a stop pin. The bevel of the pouring hole accommodates the dipper or the spout of the ladle, and the edge cuts off the "sprue" or overflow of metal after it solidifies.

The tension on the pivot screw of the sprue cutter should be sufficient to hold the cutter in firm aligning contact with the top of the block and if this screw becomes loose, metal is apt to flow in between the surface of the block and the bottom of the sprue cutter, forming a fin on the base of the bullet. If such a fin forms with the pivot screw reasonably tight, it is an indication that the sprue cutter is sprung and directions for attempting to overcome this condition are given elsewhere in this book. The stick of wood referred to above is necessary for striking the sprue cutter to cut off the sprue. Its size and shape are not important and any stick handy to use is all that is needed. A piece of old broom handle is excellent. *Neither the sprue cutter nor any part of the mould should ever be struck with a metal object.*

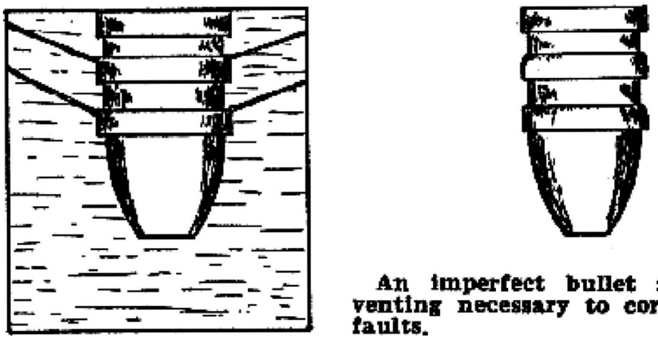
Corrosion of Moulds. Next to the individual who uses a bullet mould with more brawn than brains, the worst enemy of moulds is rust. Their oxidized film resists rust but will not prevent it. If you use your moulds frequently they can be put away with the last bullet left in them without opening the mould; that is, you can pour the mould full and leave it that, way. This will exclude atmospheric moisture fairly well for a reasonable period of time under ordinary conditions but will not serve well where the humidity is high. When moulds are not to be used for a considerable period of time they should be oiled or greased. The grease or oil should be wiped off before using the mould again or, better still, washed off as already suggested.

CASTING TROUBLES AND THEIR REMEDIES.

Failure of Bullets to Drop From the Mould. If the mould requires only slight jarring to make the bullets drop out, the condition can be ignored as a slight amount of "sticking" is unavoidable. The bullet usually persists in sticking in one certain half of the mould. Some operators tap the inside edge of that block with their stick—this is pretty apt to spring that half or cause it to warp open in time. Others tap the end of the handle in which half the bullet is stuck—this is apt to split that handle in time, but it can readily be replaced.

If one has to resort to pounding to get the bullets out there is something wrong and the mould will probably have to be returned to the manufacturer to have the defect remedied. The slightest damage to the sharp edges of the mould cavity will form a burr that will hold the bullets in and only an experienced mechanic can remove such a burr without damage to the mould. The average individual should not tamper with mould cavities in any way. Any manufacturer will correct a new mould that is at fault without charge, so it seems foolish to take a chance on ruining a four or five dollar mould.

Failure of Bullets to Fill Out. This is usually due to the mould, the metal or both being too cold. If the mould is too cold the metal will solidify before it has time to flow into all the comers. The net result will be the same if the metal is not hot enough. Sometimes mould blocks fit so closely together that the air cannot escape and with such a mould it is impossible to get good bullets unless the mould is "vented." Venting is done with a fine three-cornered file, with which shallow grooves are filed across the inside face of the mould blocks in such a way that the air may escape from the points where the bullet does not fill out properly. If the vents are filed too deep the bullet metal may flow into them when the mould and metal are very hot, but this does no harm as the projecting slivers will be sheared off when the bullet is sized. Venting can be done by anyone who is handy with a file but the file *may* slip and there is a good possibility that the file will burr the edge of the cavity. A vented mould is shown on this page which will serve better than a description of how the job is done. But remember—if a new mould does not cast good bullets the manufacturer will either vent it for you or replace it!



An imperfect bullet and the venting necessary to correct the faults.

Bullets Out of Round. Due to shrinkage of some alloys when they cool, and to small manufacturing tolerances in the moulds, bullets may be a thousandth of an inch or so out of round as they come from the mould. They are purposely cast a little over size to permit truing them up in a sizing die of the correct diameter. If the variation in diameter is greater than two or three thousandths of an inch it may be due to a faulty mould, burred or enlarged dowel pin holes or to the presence of specks of lead on the inside faces of the mould blocks. Sometimes when dropping a defective bullet from the mould into the melting pot, lead will splash upward and small drops get caught between the mould blocks. These flatten when the mould is closed but hold the blocks apart enough to cause the bullets to be out of round. Such lead flakes are easily removed with a sharp knife.

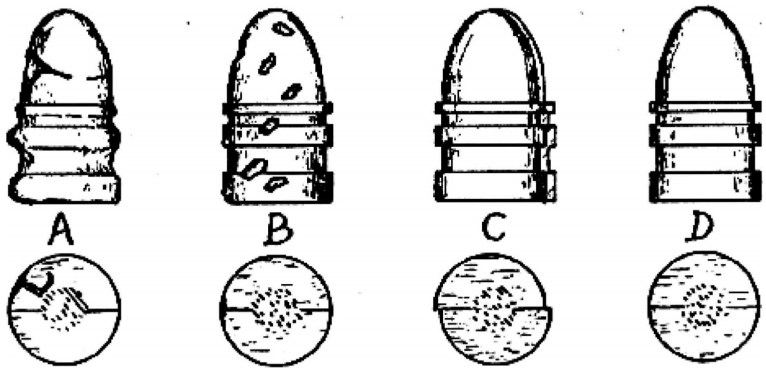
Fins on Bullets. Mould blocks do not fit together properly or sprue cutter is not flat against top of mould blocks. If sprue cutter is loose tighten the pivot screw. If the sprue cutter is bent, remove it and try to straighten it with a light hammer. Then file the under surface flat, put it back on the mould and try it. If you cannot correct the difficulty in this way you will have to get a new sprue cutter. Burrs or raised metal around the dowel pin holes can be detected with a straight edge, they are easily removed with a flat file, but care should be taken not to file across any part of the mould cavity.

Failure of Two Halves of the Mould Cavity to Coincide. The dowel pin holes are enlarged and the mould will have to be returned to the factory.

Frosted Bullets. When bullet metal cools it shows under the microscope as a crystalline formation. The size of the crystals depends upon the rate of cooling. If the metal coots quickly the crystals are small; if it cools slowly they are large. Bullets that solidify quickly in the mould will, therefore, usually have a bright shiny appearance but where the mould and the bullet metal are very hot and the metal cools slowly, the crystals will be so large that the bullet will have a frosted appearance. This difference in crystal size does no harm and has no affect on the performance of the bullet. If the mould and metal are allowed to cool down a little it will disappear but it must be borne in mind that some bullets with narrow bands, and especially bullets with hollow points and hollow bases, must oftentimes be cast with somewhat hotter metal than normal.

Folds and Seams. Either the mould or the metal is too cool.

Lead Smears On Top Surface of Mould Blocks. Usually caused by striking off the sprue when the mould is very hot and before the metal solidifies. This lead can usually be removed with a sharp knife when the mould is cold. It can also be removed with mercury. Be careful not to damage the edge of the cavity when you go to scraping around it with a sharp knife.



A.—Bullet not filled out. Metal or mould too cold. B. Effect of grease or oil in mould, C. Two halves of bullet do not match. Mould has excessive "shuck". D. Perfect Bullet.

Elliptical or Lop-sided Bases. Generally confined to very soft bullets and caused by the base of the bullet being forced to one side when the sprue cutter is struck. See that the cutting edge of the cutter is sharp. It can be sharpened with a counter-sink turned with the fingers. If a soft alloy is used this defect can be reduced by closing the sprue cutter just far enough to allow the metal to be poured.

Hollows in Base of Bullet. These occur in bullets that are cast with a very hot mould and metal. The more slowly a bullet cools the coarser the grain structure will be and the more chance of the metal breaking off at the sprue. This leaves little crystallized depressions in the bullet bases. They do no harm other than to slightly reduce the weights of the bullets and only affect the accuracy to the extent that the weight of the bullet affects it.

Manufacture of Bullet Moulds.

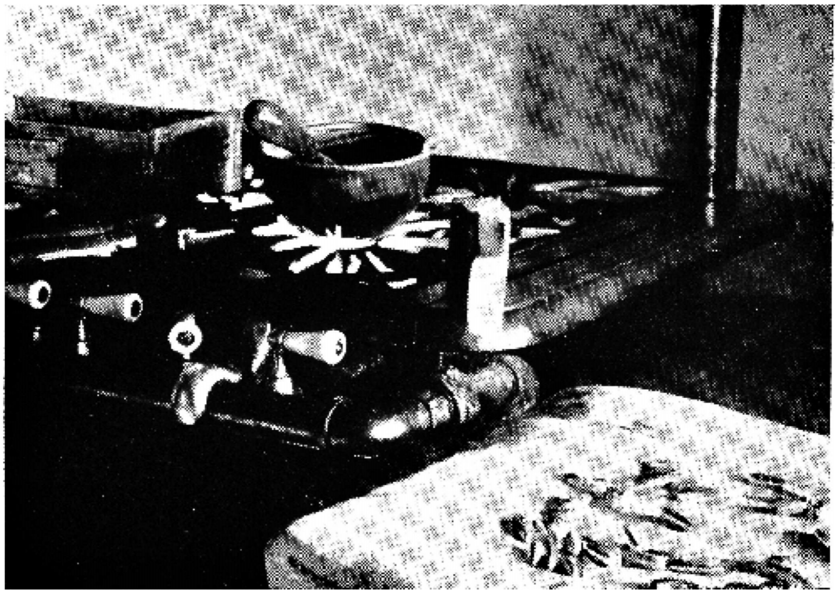
Bullet moulds are ordinarily made from blocks of malleable iron. These blocks are machined to the proper shape and size and the interior surfaces carefully ground so that they will fit perfectly together. The two halves of the mould are then clamped together and are drilled through at the proper points for the dowel pins and the corresponding holes in which the dowels are to fit. This insures perfect alignment of the two halves of the mould. A hole is then drilled in such a way that half of it is in each half of the mould block. After this the two halves of the block are brought together against a revolving cherry which is a special form of reamer that cuts a cavity the exact shape of the bullet. This sounds like a simple process and so it is to tell it on paper, but the operation is one calling for special skill and experience.

In the first place, a cherry is one of the most difficult reamers to make and frequently a lot of "fussing" is necessary before a new one will cut right. In making a cherry the stock is turned and ground to the shape of the bullet and to a size that will cut a cavity of the proper size. Ordinarily a cherry will not cut a cavity quite as large as itself unless allowed to run for an excessive length of time, and allowance must be made for this as well as for a possible shrinkage of the bullet alloy used. After the cherry is shaped the grooves must be milled in it longitudinally after which the real hard work begins for the tool maker. Merely cutting the grooves in the cherry will not leave it in condition so that it will cut, the ridges must be backed off before the cherry will cut, as the cutting edges or faces must always be the widest parts of the projections. This "backing off" is all careful hand work and the amount that the edges are backed off depends upon the kind of metal the cherry is to be used on. For example, a cherry made for cutting cavities in malleable iron would not be satisfactory for use in steel or bronze and sometimes a cherry must be worked over several times before it will cut smoothly and without chattering. Even if the clearance is correct a cherry will chatter at times. If this happens when the cavity is nearly finished, both faces of the blocks must be reground and the cavity re-cut or the blocks may be cherried out for a larger caliber of bullet.

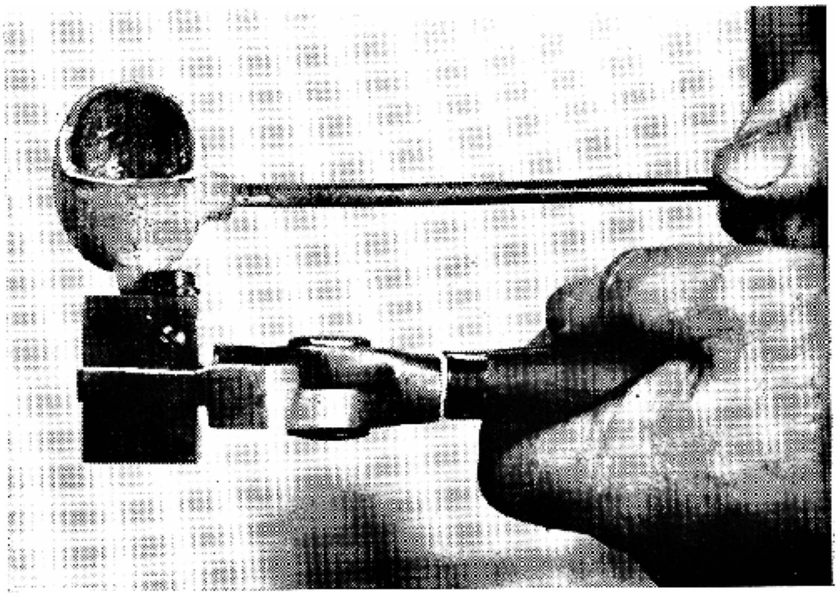
The older type bullet moulds had no detachable blocks, each half of the block being integral with one of the handles. The oldest ones had no dowel pins, but they were in general satisfactory. The objection to this type of mould was largely a manufacturing one for it was necessary to carefully fit the mould blocks before they were cherried and if anything went wrong with the cherrying the entire mould had to be scrapped. Furthermore, there was a tendency for the castings to warp under the influence of heat, throwing the two halves of the mould out of alignment. However, in spite of this many of these old moulds, including those that have no dowel pins, are still in satisfactory condition after years of use.

With detachable blocks, cherrying is more uniform from one mould to another than it used to be with the old style solid block moulds. The latter, being hinged and closing on an arc, had a tendency to squeeze the cherry away from the hinge and when this happened there wasn't much to do but pitch the mould in the creek. Nevertheless, most of the old style moulds that finally got out of the factory were pretty good and some of them were excellent.

Hard spots in the blocks make trouble and blow holes in the castings may cause uneven cutting and necessitate re-cherrying. It is not possible by ordinary production methods to cut two cavities *exactly* alike except by chance but the differences between cavities cut with the same cherry are small indeed. In moulds having more than one cavity (for same bullet) the bullets will often be of different weights. When bullets of different weights are fired they will not shoot with the same elevation, that is, the heavier ones will shoot a little higher than the light ones. The difference can not ordinarily be detected by ordinary shooting but the reloader who wishes to get the most uniform results should use bullets from one cavity; it doesn't matter which one.

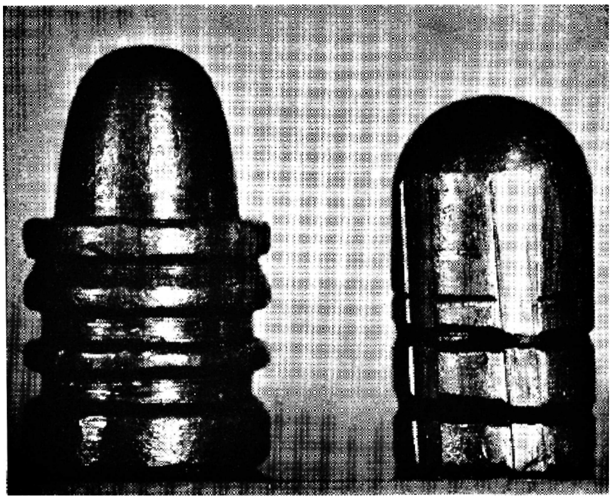


Usual "set-up" for proper casting of bullets over the gas range.

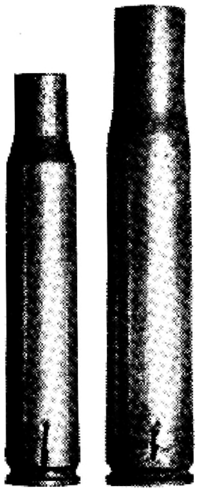


Method of casting necessary to get perfect and full bullets.

PLATE XV.



Leading Problems.
The bullet on left is not well filled out. Its rounded edges would give a different degree of leading (if any) than the same bullet with sharp bands. Bullet on right has too large a nose for the barrel it was fired in. Such a long un-lubricated bearing often causes leading.



Failures near the heads of factory loaded cartridges. These were caused by hidden defects in the brass. New cases are not a guarantee of safety when loading maximum loads nor even with loads of normal pressures.

PLATE XVI.

Mould Repairs and Adjustments.

As has been stated, when a mould does not perform properly, the best bet is to return it to the manufacturer for correction. There is not much that can be done with the old solid block moulds. If a cavity is slightly burred, it may be possible to correct it if the present cherry is exactly the same shape as the one with which the cavity was originally cut, but re-cherrying these old moulds is likely to ruin them. Moulds of this type in common use are mostly Ideal moulds, made by the Ideal Manufacturing Co., by the Marlin Firearms Co., of New Haven, Conn., or by the Lyman Gun Sight Corp. when they first started making Ideal reloading tools. All the old fixtures for cherrying these moulds have been scrapped which makes re-cherrying them of uncertain outcome and the Lyman Co., will not do any work on these moulds except at the risk of the owner. Thus far they have been lucky, probably because they will not undertake such a job unless they are fairly sure that it can be done right.

The detachable mould blocks can be re-cherried at small expense either for the same bullet for which they were originally made or for a larger caliber bullet, provided the larger bullet is enough bigger and longer so that the original cavity can be entirely eliminated. It is not possible to re-cut a mould for a different shape of bullet of the same or nearly the same caliber.

It sometimes happens that a reloader is so situated that he cannot conveniently return his mould to the factory and an attempt will be made to suggest simple ways in which a cantankerous mould may be improved or a rusted or damaged one can be made serviceable. It should be understood that work of this kind had best be done by a skilled mechanic and the novice who tries it with poor results will have to take the responsibility, as no manufacturer will correct a mould that has been tampered with, without charge.

Venting. Probably the most troublesome condition in a new mould is the failure of bullets to fill out properly. Hollow point and hollow base moulds are particular offenders, as the hollow point or base plugs cool more rapidly than the rest of the mould and have a tendency to cool the metal before it can flow into the narrow space left around these parts. Venting, hot metal and rapid casting will at least partly overcome this trouble. Failure of any bullet to fill out is caused by failure of the air to escape from part of the mould

before the metal solidifies. It may be due to the metal not being hot enough or to the two halves of the block fitting too closely together. Bullets with narrow bands are special offenders.

An old trick for correcting this, and one that has some virtue, is to put a strip of thin paper between the two halves of the mould. This will make a slight gap between the halves for the air to escape through but it will also put the bullet slightly out of round. As a matter of fact, cavities often run a thousandth of an inch or so out of round and this is one of the reasons for making the moulds a bit over size so the bullets can be trued up by sizing them to the correct diameter later.

The best remedy is venting and to do a really good job of venting a small, fine cut, three cornered file should be purchased and prepared for use in the following manner;

If the file has blank places near the end, grind the end back far enough so that there is cutting surfaces only on all sides. Then grind one side of the file flat and smooth. This will bring two edges down so the cuts on the other sides will come down to sharp, fine teeth. If an emery wheel is used, the file should be plunged into water frequently while grinding so that the heat will not destroy the temper.

Examine some of the imperfect bullets carefully and note at just what part of the bullet the air is being imprisoned; then with the file carefully file shallow grooves from the corners of the cavity that form the *bands* of the bullet. These grooves should run all the way across the faces of the mould blocks. It is not necessary to make the grooves very deep and it is best to try the mould from time to time and stop filing when the bullets come out perfect.

Sprue Adjustment. Another trouble is in the smearing of lead across the top surface of the mould and the formation of a fin of lead at the bullet base. This may be due to a sprue cutter that had been sprung by striking it in an upward direction in which straightening it as described before will correct the fault. But there is another cause. In spite of everything that has been said and published about it for the past half century or more, some fools will persist in hammering moulds with metal objects that are harder than the mould blocks instead of with a stick of wood, in order to jar the bullets out. This cannot help but burr the edges of the mould block and if the burr occurs at the top edge of the block, the sprue cutter will ride up on top of the burr, leaving a space between it and the top of the block into which metal can flow. Under such circumstances the bullets will surely have fins on their bases. If you are having trouble from fins on the bases of your bullets and suspect you are one of the misguided souls referred to, push the sprue cutter out of the way and lay a straight edge across; the top of the mould at right angles to the joint line, then move it across the top surface from front to rear. If there is a high spot on the edge of the block you will be able to see light under the straight edge. The remedy is to file off the burr, but in doing so do not file across the top of the cavity. It is only necessary, to remove the burr, not the top of the block. This will correct the trouble if the sprue cutter is not also sprung, in which case that will have to be straightened also by using a light hammer and surface plate. After all this has been done, get a stick of wood to tap the mould with.

Lapping the Cavity. Some moulds drop their bullets very nicely when opened, but they are in the minority. The average mould requires a little tapping to jar the bullets out and as long as a *little* tapping is all that is necessary, it is best to leave the mould alone. However, it is a fact that some moulds have to be pounded to get the bullets out of them. This is bad, both for the mould and the disposition of the moulder—and should be corrected. The bullet form may have a lot to do with it as bullets with flat ends or square grooves will always stick more or less. With other shapes of bullets, sticking is due to a slight burr on the edge of the mould cavity. It may be a very minute burr or feather edge but it doesn't take much to keep a bullet from dropping out. This condition can be remedied by lapping.

Cast a bullet and when it is cool, cut a groove around it where the joint line, or the mark left by the joint between the two halves of the mould, comes. Then drill a hole in the base of the bullet, as near the center as possible, and put the bullet back in the mould cavity so the groove in the bullet is at the joint line. Screw a wood screw into the hole in the base of the bullet *with your fingers.* If you use a screwdriver you may expand the base of the bullet and then that will be the only point which would bear on the cavity when the mould is closed Now twist the bullet around in the cavity, gradually increasing the pressure of the mould handles until the bullet can be rotated with the fingers with the mould closed. The reason for cutting away the joint line is, that if this is not done a ridge of lead is liable to be pinched up between the halves of the mould and the bullet cannot be rotated nor the mould closed tight.

Next, remove the bullet with the screw still in it and dip it in some flour of emery and oil or valve grinding compound; it doesn't matter whether the latter is fine or course. Put the bullet back into the cavity but don't close the mould tight enough to prevent your turning the bullet around with your *fingers.* Gradually increase the pressure on the handles again until the mould is apparently closed, then, open it, wipe off all the muck that has squeezed in between the blocks and repeat the process until you can turn the bullet with the mould fully closed. Why do I emphasize using the fingers to turn the bullet? Because it is only necessary to remove a little feather edge on the cavity and you don't want to remove any metal from the cavity itself, as that will enlarge it. This is a simple operation *but a delicate one* so don't put the end of the screw in a breast drill and grind for five minutes or so. A few turns of the bullet and lapping compound with your fingers will do the trick very nicely.

Rusted Blocks and Cavities. The above procedure can be used in cleaning out a cavity that has rusted. If the inside surfaces of the block are rusty, moisten them with oil or nitro solvent and go over the surfaces carefully with the flat edge of a screwdriver or a small scraper. You can easily remove the rust from the flat surfaces in this manner. If there is only a small spot of rust or two in the cavity you can best rub them out with a little abrasive on the end of a pine stick but if the rusting is bad, lapping with a bullet will have to be resorted to. It takes very little lapping to remove rust. After you have lapped a mould, wash it in gasoline to remove the lapping compound that may remain in the cavity.

If the mould cavity has been badly rusted and pitted, the bullets will have blotches on them. These will do no particular harm, but the pits may be rough enough to cause the bullets to stick. If, after you have lapped a rusty mould, the bullets do stick in the cavity so as to require undue pounding to get them out, prepare another bullet by cutting away the joint line and drilling it. Then put a little oil on it and stick it into some powdered graphite and proceed just as if you were lapping the cavity again, only this time don't wash the cavity out. The graphite will pack into the pits and will remain there quite a while, as heat will have no effect on it and it will not adhere to the bullets. You will be surprised how nicely bullets will come out of an apparently worthless mould when it has been treated in this manner.

Misalignment of Blocks. Fins along the joint line of the mould are due to failure of the blocks to come together properly. The mould blocks are made of soft iron and the dowel pins which align the two halves of the block are of steel. If a mould is yanked open and slammed shut, as they often are by the gentry who are imbued with the idea that nothing connected with handloading is any good unless it can be done fast, a burr will be thrown up around the dowel pin holes which will prevent the two halves of the block from

coming together. This is also the cause of some bullets being out of round, although a very slight eccentricity of bullets as cast is common and is one of the reasons for casting them over size, then truing them up to the correct diameter later. Burrs around the dowel pin holes can be removed by filing them. *Do not rub the file across the cavity* and work slowly, with a sharp, fine-cut file.

Unfortunately, the improper use of a mould not only results in setting up burrs around the dowel pin holes but it enlarges the holes, causing a condition known as "shuck", or an angular alignment of the halves of the block. There is no remedy for shuck except to return the mould to the factory. The pins must be removed, all the holes lined up and reamed out larger, and new and larger dowels fitted and this is no job for a novice without special equipment.

Chapter Seven

BULLET LUBRICANTS.

The function of a bullet lubricant, like any other bearing lubricant, is to provide a moving film between the bullet and the barrel, while the former is passing through the bore. If this is accomplished, it makes no difference what material is used for lubrication. Most of the waxes, or so-called waxes, make good bullet lubricant just as they are, but some of them have faults of a physical nature which prevents their convenient use without mixing them with certain of the softer greases.

If bullets are lubricated before they are sized, either by dipping or immersing them in melted lubricant, they must be cut out of the grease or the excess must be cut off with a cylindrical tube (the so-called kake kutter) that has an inside diameter about the same as the bullet, or slightly larger and which, when passed down over the bullet will cut or push off the excess lubricant. Some of the harder waxes do not adhere well to the smooth bullets and the fingers, which are usually sticky when doing this job, are apt to provide a more adhesive surface than the bullet and pick the lubricant out of its grooves. For this reason it is generally advisable to mix the waxes with a sufficient amount of softer grease until the mixture, in its cold state, is slightly tacky.

There is another factor that makes it necessary to soften the waxes; namely, the mechanical lubricators and sizers that are used by the majority of handloaders. These machines and their operation have been described elsewhere but in principle they provide a grease reservoir which communicates with the exterior of a perforated die. While the bullet is in the die, pressure is applied to the lubricant which is forced through the holes in the die into the grooves on the bullet. None of these machines are strong enough to handle hard waxes without excessive strain and wear. This strain with some waxes is sufficient to break the machine and with many of them the machines will quickly wear out. Lubricants for them should be of a consistency that can be forced through the machine with reasonable ease. This consistency will depend upon climatic conditions and in a cold climate a greater amount of softening agent will be required in the lubricant than in a warm climate.

The commercial lubricants sold by the manufacturers of reloading tools are all quite satisfactory and any of them will serve the needs of the reloader who does not wish to go to the bother of making his own. However, the ingredients from which these lubricants are made will not always be of a uniform consistency and the formulas have to be changed from time to time in order that the mixture may be soft enough to force through the mechanical lubricating presses.

I am very much afraid that the loading tool manufacturers pay more attention to the consistency of the lubricant than they do to the lubricating properties of the stuff that they make it from. Fortunately, they cannot go very far wrong because it is hardly possible to mix up a combination of waxes, fats or greases that will not lubricate bullets. We have already seen that the design of the bullet and the displacement of metal which takes place when the bullet is going through the barrel have a material effect upon leading, and leading can be translated into an absence or inefficiency of lubrication. Therefore, the best lubricant it might be possible to mix would not necessarily prevent leading with an improperly designed bullet or one of improper diameter for its barrel. We have also seen that the velocity at which a bullet is driven has a great deal to do with its leading. It is well to bear in mind that any increase in velocity in the bullet obtained by an increase in powder charge will also result in increased heat.

We must also consider that many bullets have broad bands and that part of the ogive or bullet nose as well as the forward band must come into contact with the barrel before the first lubrication groove can do its work. This does not mean that such bullets are not good bullets, but it does mean that the forward part of the bullet must depend largely on the lubrication that is left in the barrel by the previous shot. This is especially true of bullets having a cylindrical forward portion that is supposed to ride on top of the lands and center the bullets—but which often bear hard on one side and not at all on the other.

The amount of lubricant that remains as a coating on the bore after a shot is fired will depend upon the character and fit of the bullet and the heat developed by the powder charge. Of the materials ordinarily used for bullet lubricating purposes, very little is known of their relative lubricating properties because they are not ordinarily used as commercial lubricants and there has been little or no incentive to make any exhaustive study of them as lubricants. They will, however, all burn, so the amount of residual lubricant left in a barrel after a shot has been fired will depend upon the shape, dimensions and hardness of the bullet, the friction between it and the barrel, and the heat developed by the powder charge.

Anything that can be used for a bullet lubricant will burn and burn at a much lower temperature than it is subjected to in the barrel of a firearm. However, the time during which it is subjected to this intense heat is so short that there is normally more or less of it left in its original state on the interior of the bore. If entirely consumed, the residue, being carbonaceous and devoid of lubricating properties, may easily contribute to the leading of the barrel. Personally, I do not believe that the heat developed by any revolver loads is sufficient to burn much of the lubricant that may be left in the barrel. It may happen in rifles with the heavier gas-check bullet loads but while I have gotten leading in some guns that I can only attribute to combustion of the residual lubricant, I have been unable to prove definitely that this was the cause. When jacketed bullets are lubricated and fired at high velocities, there is a distinct trace of smoke that follows the bullet for some distance. The heat of the bullet is responsible for this and this heat comes both from friction and the gasses. If the heat of the bullet is sufficient to cause decomposition of the lubricant, the heat at the interior surface of the barrel certainly must be hot enough to do this also. Without wasting more time and space with conjectures over this possible and plausible,

but questionable detail, it can be stated definitely that it is worth while changing lubricants when leading pokes its unwelcome snoot into the picture. This is especially recommended where a barrel suddenly leads with a load that has previously been satisfactory.

Slivers of lead imbedded in the lubricant on bullets are suspected of contributing to the leading of barrels and especially revolver barrels. Some sizing dies shear off slivers of lead from the sides of the bullets and these slivers are often seen adhering to the sticky lubricant in the grooves of bullets. Leading from this suspected cause results from the slivers being blown out of the bullet grooves and into the barrel, after which they are ironed onto the bore by the passing bullet. As particles of lead are also blown from the edges of the base and bands of the bullet it is impossible to state just how much of the leading can be blamed onto the slivers. In any event, leading from this cause alone is not of much consequence and seldom causes inaccuracy. The slivers themselves, being lubricated, are usually easy to remove.

Of the materials most suitable for making bullet lubricant for reloading purposes the following are the most common; Japan wax, carnauba wax, beeswax, ozokerite, cerasine wax, tallow, paraffin, petroleum jelly or vaseline, and automobile cup greases of which there are a variety. Vaseline and cup grease are related and because of their softness are best used as softening agents for the harder waxes. The first five waxes are all excellent bases for bullet lubricant but all of them are too hard to work through the lubricating and sizing machines unless they are softened by the addition of other substances.

A brief description of these and a few other commonly available materials follows:

Ozokerite. Ozokerite or earth wax, as it is commonly called, is a mineral wax that is dug out of the ground. It is a sort of crude paraffin and varies in color from a light to a very dark brown. In its natural state, it varies greatly in consistency also, being found in some places as a soft wax and in others as a dense hard substance. Ozokerite forms the base of most of the commercial lubricants of a brown color that are sold for reloading purposes. Its natural differences in hardness are reflected in the consistency of the refined wax and it is necessary to vary the quantity of softening agents used with it according to the hardness of the particular lot of ozokerite that one gets. The melting point varies widely with the consistency or from 58° C to 100° C. Presumably the combustion point varies as well and I have known a ripple of complaints of leading to follow the distribution of a new lot of lubricant made from this substance.

Cerasine Wax. Cerasine is ozokerite refined by drastic treatment which clarifies it considerably and renders it from a light yellow color to nearly white. It is closely related to paraffin and, like it, lacks the tackyness to make it stick in the bullet grooves. It varies in consistency and the amount of softening material used with it must be varied also. Cerasine is commonly used as an adulterant for beeswax and is sometimes colored and sold as beeswax or as beeswax substitute. It is a good lubricant and there is nothing to worry about if you happen to get cerasine wax when you think you are getting beeswax. The melting point varies between 61° C. and 78° C, which is not as wide a spread as its parent, ozokerite.

Cerasine wax is the lubricant used on Filmkote and Kleenkote ·22 Long Rifle bullets. Being one of the most inert if not the most inert wax there is, it does not have much tendency to pick up grit. These bullets are lubricated by a process patented by Mr. Pedersen, the designer of the ·276 Pedersen automatic rifle that was under test by the Ordnance Department a few years ago. In general the process consists of dissolving the proper amount of cerasine wax in heated carbon tetrachloride and with the solution held at the exact temperature necessary, the bullets are dipped. The time they remain in the solution is very important for if removed too quickly, the coating of wax will not only be too heavy but it will chip off easily. It is quite a trick to do even with the proper temperature control and entirely impracticable without special facilities. When the bullets are removed from the solution, the tetrachloride volatilizes out leaving a thin and almost imperceptible film of wax on the bullet.

The Pedersen automatic rifle operated on the delayed blow-back principle and did not function too well with dry cartridge cases, especially if the cases were hard and did not stretch much, as the setback of the case was necessary to good functioning. As a dry case normally grips the chamber walls, Mr. Pedersen developed this method for lubricating the entire cartridge with cerasine. The thin coating left by his process was not noticeable, did not pick up dirt readily and the chamber heat caused the wax to melt, affording perfect lubrication and certain functioning. The use of this wax in such a thin coating on Cal. ·22 bullets offers a good example of its excellent lubricating properties.

Heel-Ball. This is the black, waxy residue obtained from the refinement of cerasine and it is ordinarily used to give a polished finish to the heels of shoes. It is obtainable in almost any community but whether or not it is any good for bullet lubricant I do not know as I have never been driven to the extreme of using it. As it is really the dregs of ozokerite, I suspect that its lubricating properties are limited,

Carnauba Wax. This is a vegetable wax obtained from a species of palm tree found in Brazil and some other tropical countries. It is dark in color, almost black, and quite hard. Its lubricating properties are good. The melting point varies between 72·5° and 85° C. Carnauba wax, because of its hardness and the lack of a tendency to pick up grit, makes a good lubricant for outside lubricated bullets.

Beeswax. This wax is too well known to require description here. It makes a good bullet lubricant and is obtainable almost everywhere. Although beeswax is often adulterated with cerasine, this makes no difference as cerasine is excellent as a lubricant. Beeswax is "stickier" than cerasine wax and requires less softening than the latter to make it stick to the bullets. The melting point of unadulterated beeswax is 67·2º C. A time honored bullet lubricant can be made from beeswax, by adding enough machine oil to make it the desired consistency. The machine oil should be kept to the minimum necessary to do this, as in the hot sun there is a tendency for the oil to exude and it may seep down into the powder if there is an excess present.

Japan Wax. This is a vegetable wax obtained from an oriental tree and it is an excellent bullet lubricant. It runs fairly uniform in consistency with a melting point from 55º to 60° C. The specifications for the U. S. Cal. ·30 gallery practice cartridge, which was loaded with a lead alloy bullet, called for pure Japan wax as the bullet lubricant and it has also been used by the commercial ammunition manufacturers for lubricating lead bullets. The pure wax is too hard to work through the Bond and Ideal lubricators and sizers but it can be softened with vaseline or sperm oil.

Tallow. Tallow is an animal fat with excellent lubricating properties but, in common with other animal fats, it is liable to become rancid in warm climates. It varies in consistency and is so soft that it can seldom be used as a softening agent for the waxes except in cold climates. Its melting point is from 42·5° C to 46° C, which is only a little over 100° F. and ammunition often attains this temperature when exposed to the sun in temperate and tropical climates. Under the influence of warmth, tallow liquifies and the resultant ooze is liable to work down into the powder and primer. But in this respect, tallow should not be compared with oil as a softener for the waxes. Tallow is a solid at ordinary living temperatures while oil is a liquid and consequently, oil is much quicker to exude under the influence of heat than tallow. Put a piece of tallow on a sheet of paper where it is exposed to the rays of the sun and

in a short time there will be a grease spot on the paper but a drop of oil will permeate the paper at once. Tallow is better than oil for a softener, except under conditions where it is likely to go rancid.

Paraffin. Paraffin is a white mineral wax of good lubricating properties and is related to ozokerite and cerasine. Like all mineral waxes, paraffin does not have the tendency to stick to bullets like some of the true waxes have. The use of paraffin is indicated where a bullet lubricating mixture is too soft and sticky. A small amount of it added to the mixture will harden it and reduce the tackyness. Melting point 55° C.

Petroleum Jelly. Otherwise known as vaseline. It is of the same general chemical composition as paraffin but much softer and is one of the best substances for softening waxes. Being a mineral product, it will not turn rancid, it has good lubricating properties and, as its melting point is fairly high, it is not so likely to exude into the powder charge as is mineral oil.

Machine Oil. A mineral oil related to the mineral waxes and may be used sparingly with them as a softener. It combines better with them than with animal or vegetable waxes. Being normally a liquid, there is a tendency for mineral oil to seep out of bullet lubricant under the influence of warmth and this is especially true if the lubricant has a vegetable or animal wax base. Being of mineral origin, it combines better with the mineral waxes.

Castor Oil. This is a well known lubricating oil of vegetable origin and can be used as a softener for the vegetable waxes, but tallow or vaseline are cheaper and work very well.

Sperm Oil. Real sperm oil is in reality a true wax in spite of its name and liquid form. Its excellent lubricating properties are well known and it serves well as a softener for the animal waxes. But much of the so called sperm oil on the market is either adulterated or is a downright substitution of a certain kind of fish oil. It can be relied upon to be the real thing only when purchased from a reliable dealer. However, it doesn't make much difference whether it is pure or not for, when oil of any kind is used as a softener, only a small amount is required. It is the wax base of the lubricant that does most of the business, so there is not much object in being too fussy about the oil when the latter is used as a softener.

Graphite. Graphite is neither a wax nor a grease but it is a good lubricant if used judiciously. Flake graphite is not suitable for use in bullet lubricant and the finest powdered form available should be used and used sparingly. Ten per cent by volume added to the lubricant is sufficient and an excess should be avoided, as too much will build up in lumps in the barrel. The graphite should be stirred into the melted lubricant and the stirring continued until the mixture cools, to prevent the graphite from settling to the bottom. This method of mixing will not always result in an even distribution of graphite through the mass and it is better to work the cold lubricant with a fork. Putting it through a meat chopper several times has also been recommended but I suggest the fork, if you want to remain on good terms with the cook. Graphite lubricant can only be used satisfactorily in a lubricating and sizing press. If it is melted, the graphite will settle to the bottom. The effect of the graphite, if it happens to work properly, is to leave a thin coating on the inside of the bore and as it will stand very high temperatures, there is no danger of its burning off. It should not be understood from this that graphite in the lubricant will certainly prevent leading and—if it is not used correctly, its questionable benefits will not offset the mess and bother of making it.

Factory lead bullets are often tumbled in graphite and pick up a thin surface coating of it, this probably helps somewhat to prevent these bullets from leading. About the best that can be expected from a lubricant containing graphite is, that the coating it may leave in the bore will about equal the light coating that is on the factory bullets. As long as there is a film between the bullet and the barrel, it makes little difference whether it is on the bullet or the barrel.

Colloidal Graphite. This is a substance that has appeared on the market quite recently. It is merely graphite which is so finely divided that it remains in suspension in the vehicle with which it is mixed. Lubricants containing this are much superior to those made with the ordinary powdered graphite's, as the colloidal graphite will remain in suspension even when the lubricant is melted. In fact, even when the lubricant is liquified or cut with a suitable solvent, only a very small percentage of the graphite will settle to the bottom of a test tube. Aside from its colloidal nature, colloidal graphite is still graphite and should be used with discretion. An excess should be avoided.

Mixing Bullet Lubricants.

In discussing the various materials suitable for bullet lubricants, no attempt has been made to give specific formulas or mixtures. It is impracticable to do so as so much depends upon the consistency of the ingredients used. It is a simple matter to mix bullet lubricants. Melt the wax first and add a *small* amount of softener. Mix the mess thoroughly and pour a small amount onto a plate or other cold surface and let it cool well. Then scrape it off the plate and work it in your fingers. If it is too hard when you try to work it, or if it is slippery and does not stick to your fingers, add more softener and repeat the process. If it is too soft and sticky, add more wax. Remember that the hardness of a lubricant depends upon the way it is worked and the more you work it, the softer it will become, up to a certain limit, of course. But a lubricant that seems to be quite hard when you touch it after it has cooled, may be rather soft after it is worked. Squeezing the lubricant through the holes in a lubricator die works it considerably and you must make allowances for this when mixing the ingredients. A lubricant that may seem to be just right to the touch, once it has cooled will probably be too soft after it is forced through the lubricator. The whole business is a case of "cut and try."

CHAPTER EIGHT

BULLET SIZING AND LUBRICATION.

Bullets and their sizing and lubrication are subjects so closely related to one another that it is impossible to consider them separately. Consequently, there is some overlapping of these subjects that cannot be avoided, especially when lead alloy bullets are involved.

Jacketed bullets, as made in the United States, require no lubrication nor do they have to be sized in any way as they are made correctly for the cartridges they are intended to be used in. The ·303 British service bullet which uses a cupro-nickel jacket, has a shallow groove filled with lubricant, the groove being covered by the case neck.

Some seventeen or eighteen years ago when our own military rifle shooting was all done with the old Model 1906 cartridge, loaded with a cupro-nickel bullet, riflemen used to lubricate the bullets externally. The cupro-nickel jackets, at velocities of over 2,000 f. s., left a thin deposit of metal fouling along the muzzle end of the bore for about 6 inches. This fouling would build up in lumps and streaks, impairing the accuracy of the arm until it was cleaned out and the cleaning was a troublesome process. Someone got the idea that lubricant on the bullets would prevent this metal fouling. A rifle was taken out on the range and fired a limited number of rounds with bullets that were dipped in and thinly coated with Mobilubricant, a heavy automobile grease. The rifle did not metal-foul as might normally have been expected and without more ado Mobilubricant was hailed as a panacea for metal fouling.

For several years one couldn't find a rifleman on the line without his little tin box of Mobilubricant in front of him. For slow fire the bullets were dipped one at a time and for rapid fire the bullets of all the cartridges in the clip were greased before they went into the magazine or the belt. But during this period, the Ordnance Department began to get an increasing number of rifles with cracked bolt lugs or worse. Investigation finally disclosed that the Mobilubricant was causing the trouble. The greased bullets, rubbing against the hot chamber left grease in the chamber, or resting in the hot barrel for several seconds before firing, the grease melted and the excess leaked back into the chamber.

A cartridge case under normal conditions grips the walls of the chamber when the cartridge is fired but with lubricant in the chamber there was no grip and the case was driven violently back against the bolt face with more force than a rifle bolt is made to stand. As some shooters put great gobs of grease on their bullets, it is probable that in some instances the grease filled practically all the normal clearance between the cartridge, reducing the expansion of the cases and causing higher pressures than usual. In any event, a thorough investigation was made of the virtues of external lubricant on jacketed bullets and it was found that it really had little or no affect on metal fouling. Proper publicity was given this, as well as to the dangers of lubricant in chambers, and the practice disappeared as promptly as it sprung up.

The method of measuring chamber pressures in small arms in Great Britain utilizes the set-back of lubricated cartridge cases, the copper crushers occupying a place between the head of the cartridge case and the face of the bolt of the special guns made for this purpose.

However, the practice of lubricating jacketed bullets is passe and is entirely unnecessary with gilding metal bullets anyway. Cast bullets when loaded in old black powder arms, with one or more lubrication grooves exposed, should be loaded into the chamber carefully to avoid greasing the chamber walls. The margin of safety of some of the older arms is not too wide, even with black powder loads.

Lead or lead alloy bullets cannot be fired with accuracy unless they are lubricated. If un-lubricated, or if the lubricant is not of the proper nature, lead will rub off on the inside of the barrel and destroy its accuracy until cleaned out. For this reason, cast bullets are provided with grooves to carry lubricant, and these grooves must be filled in one way or another before the bullets are fit for use.

A bullet, as it comes from a mould, will probably contain some little irregularities. Most moulds cast bullets a few thousandths of an inch over size to allow enough surplus metal so the bullets can be trued up perfectly round and to the correct diameter by forcing them through a die of suitable size.

The best way to size and lubricate bullets, is with either the Bond or Ideal bullet lubricating and sizing presses. They are both of the same general design, operate the same way, and do equally good work. Any reloader will do well to equip himself with one or the other of these little machines, especially one who does a considerable amount of reloading.

But bullets *can* be sized and lubricated perfectly by two separate operations. The bullets are *first* lubricated and then forced through a resizing die. All of the reloading tool manufacturers can furnish bullet sizing dies that are either used as attachments for their reloading tools or separately.

Many of the older Ideal Tools have bullet sizing holes through the handles, through which the bullets are intended to be forced point first. Unfortunately, this usually does more harm than good to the bullets, as the excess metal is forced back and sometimes makes ragged bases on the bullets. Furthermore, the bullets are apt to tip as they come out, which further deforms the bases. This type of construction has been discontinued but, if you have such a tool, good results can be obtained by forcing the bullets through the hole *base first.* This will probably result in some slight deformation of the bullet point from the pressure of the plunger, but this is by far the lesser of the two evils. A better remedy is to get a bullet sizing chamber for the tool if it is of the adjustable type, or one of the several bullet sizing tools on the market.

There are two simple, if somewhat messy, ways of lubricating bullets. The first and oldest method is to stand the un-sized bullets on their bases in a shallow box or dish and pour melted lubricant around them to a depth that will cover all the grooves. After the lubricant solidifies, the bullets may be cut out with a "kake kutter," which is a name given to a cartridge case with the head cut off or bored out and the mouth sized slightly larger than the bullet diameter. Any tubular article of suitable size, through which the bullets can pass freely, will do. The bullets are picked up by the kake kutter as it is pressed down over the bullets one after the other, the preceding bullets being forced up and out the top. As each bullet is forced out, take it with the fingers and set it down carefully, so the base will not be damaged.

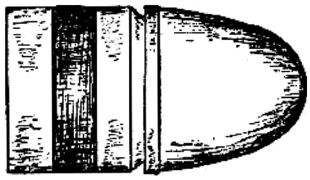
This will leave your bullets in a condition that can be best described as a gooey mess, but they should not be wiped off. The next step is to force them through your bullet sizing die. This will size them and help to force the grease into the grooves. It will also scrape off much of the excess lubricant. In handling the bullets, try to avoid picking them up where the lubricating grooves are

located. The lubricant is liable to adhere to your sticky fingers better than it does to the smooth surface of the lubricating grooves. After the bullets are sized the surplus lubricant can be wiped from the bases and points of the bullets. They should then be packed neatly in small cardboard boxes so they cannot tumble about and damage their square bases.

Bullets can also be lubricated by holding them with the fingers and dipping them, one at a time, into melted lubricant, then standing them on their bases on a sheet of paper or tin. The lubricant will coagulate on the cool bullet and the excess is cut off with a kake kutter as described above. This is the best method of the two; it is quicker and possibly a bit cleaner.

There are a few bullets that have bands of different diameters that are not intended to be sized. The Belding & Mull, Squibb-Miller, and Ideal Pope bullets are notable examples of this type. These bullets must be lubricated by hand as just described.

Were it not for the leading which will result from the use of dry bullets, the problem of reloading ammunition would be greatly simplified; therefore, the subjects of bullet alloys and bullet lubricants are closely related, and a word about the distribution of the lubricant on the bullet will not be out of place here.



The idea of lubrication is to have a film of lubricant between the surfaces where friction is likely to occur. Many bullets are poorly designed with respect to the location of the lubrication groove or grooves, and many of them, especially revolver and pistol bullets, have only one wide groove. The drawing on this page is typical of such bullets, and shows how more than 50% of the bearing surface of the bullet must come into contact with the barrel before any lubricant in the groove becomes effective. The lubrication of the forward part of a bullet of this kind is dependent upon the lubricant left in the barrel from the preceding shot, and the amount and virtue of this residual lubricant will depend upon the composition and consistency of the lubricant used, as well as the bullet alloy.

Use of Grease or Wax Wads.

The practice of using a wad of wax, or wax softened slightly with grease, under the bases of bullets, either with or without a card wad between them and the powder, is as old as breech loading arms. The practice has had a recent revival and it is claimed that the use of colloidal graphite in the wads has some particular virtue in preventing leading in revolvers and reducing erosion in some rifles. Perhaps it has, but the practice of using fusible wads of any kind behind bullets should be approached with caution.

As has been explained elsewhere in this book, there is every indication that the neck of a cartridge case expands before the bullet moves forward to seal the bore and that a certain amount of gas escapes between the case neck and the bullet. This is a normal condition and the escapage of gas influences the chamber pressure. If the case neck and the chamber are such a close fit that there is no expansion of the neck and no escapage of gas past the bullet, the pressure developed by the charge will be materially higher than normal. This is the condition found in special tight chambers.

When a wax wad is used under a bullet, the density of loading is increased, if the bullet be seated to its normal or prescribed depth, which, if not influenced in any other way, will cause some rise in pressure. If the clearance between the expanded case neck and the bullet be small, the melted wax will seal the space, just as oil in an engine cylinder seals the gas from passing the piston. This will cause a considerable increase in the chamber pressure and create a condition analogous with that of the tight chamber. Therefore, if a fusible wad is used under a bullet, I would suggest in the interest of safety that the thickness of the wad be considered as part of the seating depth of the bullet and that any full charge of powder be reduced at least two grains in weight, just as when loading cartridges for tight chambers. This applies especially to the newer cartridges such as the ·257 Roberts and the ·220 Swift, as these calibers have a closer relation between case necks and chambers than some of the older calibers. I also believe that any reduction in erosion obtained from the use of grease wads is due to their effect in preventing the gasses from rushing past the bullet plus possibly some lubricating effect between the unburned powder grains and the barrel.

Where there is several thousandths of an inch between the expanded neck of the case and the bullet during the cycle of combustion, or when the clearance is great enough to permit the melted wax or grease to be blown past the bullet, the increase in pressure will not be so great but unless the clearance be considerable, there will be more or less increase. We can compare the effect of a grease base wad in a tight chamber with a normal automobile cylinder in which the oil seals the gas above the piston and the normal chamber with an automobile that pumps oil. The difference in both cases is purely that of the amount of clearance between the moving metal surfaces.

The effect that these grease base wads have on pressures can only be determined with a pressure gauge but the effect on lubrication can easily be seen by anyone interested enough to make a simple experiment.

Any normal military rifle is all right for making the test which is as follows: Cast up some bullets of any alloy but do not lubricate them. Load ten of them, dry, with a moderate charge of powder and fire them. Ten will be enough to give the barrel a nice dose of lead. Push a dry patch through the bore to remove the surface powder fouling and any loose bits of lead and observe the condition of the bore so you will have a good mental picture of it for later comparison. Then, scrub as much lead out as possible with a dry brass bristle brush, plug the chamber tightly with a cork or wooden plug and load the barrel with metallic mercury to remove the remaining lead. There will probably be from six to ten inches of it and it must be completely removed. Incidentally, if the arm is ordinarily used with lead bullets it should be doped with mercury before you start the test. Thoroughness and uniform conditions are necessary if the results are to be of any value at all.

When all the lead in the barrel is amalgamated and the bore wipes out clean, repeat the process exactly as before *except* that the bullets must be seated on top of wads of wax or grease. Anything that you use for bullet lubricant will do and the wads do not have to be of any exact thickness. I suggest a thickness of from 1/32 to 1/16 inch. The results you get this time will depend upon the amount of powder used and may vary from no leading at all to a fair amount for a short distance, starting a couple of inches ahead of the

chamber. The heavier the charge, the farther the leading will extend along the barrel and the more it will build up but with a light or moderate powder charge it will not amount to much and most, if not all of it, will come out with a little wire brushing. Always wipe the bore with a dry patch before examining it, as otherwise you may mistake powder fouling or other corruption for leading. The point is that some of the grease from base wads does blow past the bullet under the circumstances mentioned and lubricates the bore ahead of the bullet.

A few points to observe are: to wash all oil from the bore before firing each test; wipe the bore with a dry patch before examining it; use bullets from the same lot, and if the charge is a light one, use cases that have been expanded by previous firing without sizing the necks. The bullets can be held in good enough by crimping.

Because of the gas-check effect that the grease has in a tight chamber, their use can be considered as dangerous with heavy loads.

In revolvers, the use of a grease wad under the bullet is not so serious as there is usually plenty of expansion of cases in such arms. If over sized bullets are used the situation may be changed, as the whole idea depends upon the clearance between case and bullet and may be very different in two different calibers or even two arms of the same make and caliber.

Grease or wax wads should be of a fairly hard consistency and should remain solid at any ordinary temperatures under which they are likely to be used. Otherwise, they may melt and run down into the powder charge, preventing all or part of it from burning properly. There is some indication that the powder which comes in contact with grease wads does not burn but that is getting into someone else's thunder, which is out of my line.

Making Grease Wads. These wads can be made from any bullet lubricant that is normally satisfactory for lubricating bullets in the usual manner. The only advantage that one substance will have over another will be in its intrinsic lubricating properties, as it will function in the same way whatever it is made of. If the wads are to be cut out and handled separately, they will have to be a little harder than ordinary bullet lubricant. They can be made by dipping a bottle or glass plate into the melted lubricant and removing it quickly. The wax will coagulate on the cold surface, leaving a coating that can be stripped off before it sets up hard. If the mixture is too soft, you won't be able to get it off the glass in a sheet. After it hardens, the wads can be cut out with a wad-cutter made from a cartridge case with the head cut off and the mouth sharpened a little by beveling it with a knife. Wads made in this way are usually very thin and for thicker ones, the melted lubricant can be poured onto a glass plate. Grease wads are most easily and nicely handled by leaving the lubricant on the glass. After the cases are charged, the mouths of the cases can be pressed *up* against the plate and slid off, each case cutting its own wad perfectly. In seating the bullets, the bases should not go in far enough to push the wad back into the body of a bottle neck case for, if the wad fails to stick to the bullet base, it will be ineffective. Seating them that deep is inadvisable anyway.

Bullet Sizing.

Now, about sizing bullets; most of that has been gone over under the subject of “Bullets” but bullets are lubricated to prevent leading and the way they are sized has much to do with this. Many of the newer bullet moulds, especially those for rifle bullets, drop their bullets so large that they cannot be sized down to a proper diameter without nearly obliterating the lubrication grooves. One of the things that you will observe, if you try that little leading experiment just mentioned is, that at low velocities, there is very little tendency for a bullet to lead a barrel once it is fully impressed into the riding; it has reached a point where the base is no longer expanding and is only sliding along through the bore. And this with a dry bullet too! As the velocity is increased, there is an additional thrust against the driving edges of the lands and the leading is carried farther up the barrel. As the velocity increases the leading increases and the higher the velocity the more important proper lubrication becomes.

Let us suppose that we have one of these gosh awful Cal. ·30 bullets that casts about ·316″ to be sized to ·311″ which is ·003″ too large for most Cal. ·30 barrels. Sized to ·311″ it carries a fair amount of lubricant as we look at it, but when fired the lands not only cause lead to be displaced back over the lubrication grooves but the whole surface of the bullet must be swaged back as well. We can't size the damned things down to ·308″ if the bullet has a gas-check as trying to force a ·311″ gas-check through a ·308″ die will bust the lubricator. If we could, we would see the grooves considerably decreased in width and made more shallow. Narrow grooves would practically be wiped out. Whether the sizing is done in a die before the bullet is loaded or afterward in the barrel, the net result is the same.

If one of these bullets is driven at a high velocity, the lubrication that it carries may hold out till it gets to the end of a 24″ barrel but be insufficient to take it out of a 30″ barrel. Actual tests have shown such bullets to lead six inches of a long barrel enough to destroy the accuracy, but by reducing the velocity considerably they would get all the way through without leading. Which comes right back to the effect of velocity on leading.

Somewhere else I have referred to the edges of the bases and bands of bullets being blown off by gas rushing past the bullet before it moves up into the rifling. (See “Revolver Cartridges”.) The same thing happens to rifle bullets in normal chambers and, it is reasonable to suppose, a certain amount of lubrication is blown out of the grooves at the same time. In a rifle, all of this lubrication is blown into the barrel but in a revolver it is not and more or less of it escapes between the barrel and cylinder. After firing the latter arm a dense, greasy residue is always found plastered around the rear end of the barrel. This means less lubricant on the surface of the bullet, where it is most needed. The heavier the powder charge, the more lubricant blown out of the grooves and just when the bullet needs it most because of the higher velocity. Revolver bullets should not be sized large enough to fit the throats of their chambers and consequently, there is no way to check this loss. It gives no trouble with properly designed bullets at normal velocities.

Now let's see if we can briefly gather together in a concrete resume some of the scattered generalities about sizing bullets, here where they will be available for ready reference.

1. Cast bullets for rifles should be sized to not less than the groove diameter of the barrel they are to be fired in, and those for revolvers should be so-called standard diameters or the diameters of factory bullets of the same caliber— unless there is some very definite reason for doing otherwise.
2. The ability to size bullets to their proper diameter is limited by the design of the bullet and its size as it comes from the mould. Many moulds cast bullets that are entirely too large. If these bullets are sized down to the normal groove diameter of the barrel of their

caliber they may size off center and the lubrication grooves will be decreased in width and depth to a point that may easily cause leading.

3. The exact method or tool used for sizing bullets is not important except; that they should never be sized point first. When sized base first, the die or tool should have a recess that will receive the bullet as cast and *center* it over the reducing part of the die. Top punches of lubricating and sizing tools or of sizing tools and chambers *should fit the points of the bullets properly,*

4. The apparent off-center sizing of bullets is more often due to a slight eccentricity in the bullet as cast rather than to lack of alignment of the sizing die and punch.

5. There may be a tolerance of about ·0005″ from the diameter marked on a bullet sizing die. This tolerance is almost always on the plus side and is of no practical consequence.

Things to remember:—

That the size of a cast bullet has an effect on leading in addition to the amount and kind of lubricant used, the velocity at which the bullet is driven, the heat and pressure developed behind the bullet, the tolerance in the neck of the chamber and the amount of gas that escapes past the bullet before it moves into the rifling, the melting point of the bullet alloy and the hardness of the bullet.

The more the diameter of a bullet exceeds the groove diameter of the barrel it is fired in, the more apt it is to lead the barrel. The reverse seems to be true with some bullets in revolvers but this is due to the lesser reduction of the lubricating surface of the larger bullet plus a smaller escape of gas past it due to its filling the throat of the chamber better. This sometimes has a beneficial effect in a short revolver but seldom in a rifle barrel. However, the causes of leading are so many and so inter-dependant that no hard and fast rule can be laid down.

Bullets cannot be arbitrarily sized smaller to reduce leading. Everything depends on the design of the bullet and whether it’s as-cast dimensions will permit the reduction in size.

CHAPTER NINE

MECHANICAL POWDER MEASURES.

The Ideal, Bond and Belding & Mull powder measures are very convenient and useful devices for measuring powder charges rapidly and with sufficient accuracy for any purpose excepting long range target shooting and for maximum charges. The method of using these measures is described in the literature of their respective manufacturers so there is no need of repeating that here, but it is pertinent to explain the principles underlying their operation and their limitations.

The Bond and Ideal measures work on much the same principle. They have powder reservoirs, below which are rotating parts that can be adjusted to provide a measuring cavity of variable capacity, the cavity being adjusted according to the kind and volume of powder desired. The measuring devices are provided with graduations that serve as reference marks for setting the measures and the manufacturers furnish tables by means of which their measures may be set for any desired charge of any kind of powder.

The Belding & Mull measure differs from the others in its operation, although it is the same in principle. It has a measuring device that takes the form of an adjustable cup or measure entirely separate from the rest of the apparatus. The capacity of the measure proper can be adjusted for the charge desired and after it is charged, the powder is dumped into the cartridge case with the aid of a funnel. This is somewhat similar to the old-fashioned dip measure, but is much more accurate and convenient.

The two questions that arise in regard to mechanical powder measures are, how accurately may they be set by their graduations and, how uniform will the charges be thrown after the measures are set? There is no definite answer to either question. Much depends upon the way the measure is operated, the kind of powder, the quantity used in each charge and the shape and dimensions of the measuring cavity. If the measure be not operated smoothly and uniformly, the charges cannot be uniform, although with the most careless operation of any of these measures, the charges thrown will not vary more than those found in the ordinary run of factory ammunition.

The kind of powder makes a difference in the uniformity, because some powders have smaller grains than others and consequently flow more smoothly. Coarse grained powders do not measure as uniformly as the finer grained ones. Even the humidity affects the way the powder flows and as a general rule, powder will not flow as smoothly in damp as in dry weather, even though the moisture in the air has no effect on the burning of the powder after it is loaded, at least no effect that the reloader can detect.

The shape of the cavity also affects the uniformity of charges. If one were to select a certain kind and charge of powder and adjust all three measures to throw the same weight, it might be found that one measure seemed to measure that charge a little more uniformly than the other two, but if the kind of powder were changed and the measures set for a greater or smaller volume, the advantage would very likely switch to one of the other measures. A noteworthy example of the effect of the dimensions of the measuring cavity on the uniformity of powder charges is found in the Ideal Micrometer Powder Measure. This measure has one rather thick measuring slide, by means of which the cavity size is governed. The depth from front to rear and from top to bottom of the cavity is fixed by the width and thickness of the slide. The width of the cavity is controlled by the amount that the slide is drawn out. When this measure is set for small charges of pistol powders, the cavity is so narrow that the powder cannot flow into it uniformly and used in this way the variations in the weights of successive charges are greater than are considered permissible, therefore the manufacturer does not recommend this measure for use with pistol powders. The Ideal Universal Powder Measure provides a broad, shallow cavity for pistol powders and handles these charges very nicely.

Assuming that we have one or another of these measures, let's look at the successive steps in setting and using it in order to get the most uniform results, for the accuracy of the ammunition will depend more upon the uniformity of the successive charges thrown than on the precise weight of the charge.

Powder Measure Graduations and Settings.

Bond and Ideal Powder measures are graduated in grains weight of Black Powder, but in using them with smokeless powder the graduations should be considered merely as arbitrary reference lines. The Belding & Mull measure has arbitrary graduations that have no particular relation to any one kind of powder. This is just as good a system and perhaps better than trying to tie the graduations up with *one* kind of powder. I think that this idea of trying to explain and reconcile black powder graduations with the settings for smokeless powders is one of the most confusing things ever put forth for the beginner at reloading and I would suggest that anyone not loading black powder forget all about the black powder graduations on the first two measures mentioned. As a matter of fact, all the different granulations of black powder bulk differently in a measuring cavity of any given volume and charges of fine grained black powder will be heavier than charges of coarse grained black powder when measured in the same volume, which doesn't make any difference as Black Powder should be measured by VOLUME and *not* by WEIGHT.

The principle of any of these mechanical powder measures is simple and satisfactory. They all have adjustable measuring cavities. They all measure by VOLUME and *not* by weight. The larger the cavity is made, the larger the volume of the charge it will measure and consequently the greater the weight of the charge. Tables for setting the measures are furnished with them. In all of these tables there is a column for each kind of powder. To measure any charge, select the column representing the kind of powder you are going to load, select the weight of charge you want, and set the measure on the graduation indicated by the table for that weight and kind of powder. That's all there is to it.

The graduations on powder measures are evenly spaced and doubling the number of graduations of the setting will double the volume and the weight of the charge, regardless of the kind of powder used. Powder measure tables are usually computed on this basis, the results being checked by setting the measure at different volumes and actually measuring and weighing the charges thrown. The *average* weight of several charges is the weight shown in the table for the particular setting given.

Due to the difference in densities of different lots of the same kinds of powders, mechanical powder measures can only be depended upon to throw *approximately* the weight of charge desired when set according to a fixed table. Actually, the charge may be slightly lighter or heavier than is indicated by the table, but it will not be enough different to worry about as long as it does not exceed a normal full charge. Maximum charges should never be measured; they must be weighed. Where it is desired to get the greatest degree of accuracy of charge, scales or balances must be used, but the mechanical powder measures will, when used properly, throw charges with all the uniformity necessary for extreme accuracy with all but the coarsest grained powders. Even with coarse grained powders they do surprisingly well if the ammunition is judged by its performance rather than the mental contortions of a novice handloader who has been misguided into believing that any powder charge that varies more than one tenth of a grain in weight is inaccurate. No one can be criticized at all for taking all the pains and time necessary to get uniform charges of powder into reloaded ammunition, but the average reloader has an exaggerated idea of the degree of uniformity necessary to get first class accuracy. Our present day factory ammunition is pretty fine stuff, but how do you suppose the powder charges are loaded. By weighing? Not by a dawgone sight! They are measured by volume, in gravity powder measuring devices that work very much on the same principle as the measures used by handloaders. The latter, however, has a little the advantage because he can take more time and care with his loading and by careful use of a mechanical measure, can get a greater uniformity of charge than is possible on a loading machine. Naturally, the question arises as to how to use a powder measure to get this extra accuracy. Granting that the nature of the powder, as well as the very principle of bulk measurement, imposes some limitations on the accuracy that can be obtained with certainty, any mechanical powder measure is subject to certain conditions and if these are observed by the user, he will get all the accuracy and uniformity of charges that his powder measure is capable of.

Hints on the Use of Powder Measures.

The Ideal and Bond Powder measures work on the same principle but the Belding & Mull measure is a little different. We will consider the first two together and the latter by itself.

When powder is emptied from a canister into the reservoir of a powder measure, the grains fall in a hap-hazard manner and the powder column is “loose” and of an uneven density. If the measure is used with the powder in this condition, the jarring incidental to the operation of the measure will cause the powder to settle and increase in density and the charges will increase in weight, from one to another, until the powder reaches its maximum density. By maximum density is meant that the powder has settled as much as it possibly can.

Therefore, after emptying powder into a measure, the measure should be tapped or jarred until the powder will settle no further, before the measure is used to load any ammunition. But jarring the powder column to its maximum density is not enough to insure uniform charges from the start.

Most of us have at some time in our lives played with a funnel and sand. When the funnel is filled with sand and the sand is allowed to flow out of the spout, the sand flows in toward the center, or directly over the outlet, forming a moving column down through the mass. The sand at the outside of the mass does not move down appreciably until the widening cone in the center reaches the sides of the funnel. In moving in this way, the sand particles slide one upon another and arrange themselves into what may well be called “lines of flow.” If the sand be coarse and rough or if it be damp, it will not flow with the ease and freedom of fine, dry sand.

Powder works the same way in a powder measure. True, it does not flow unrestricted through an opening in the bottom of the measure, but its principle movement downward is through the measuring cavity and after a varying number of charges have been thrown, lines of flow are established in the powder just as they are in sand when passed through a funnel. With a measure set for a small charge of pistol powder, it may be necessary to throw quite a considerable number of charges before the lines of flow are established, while dumping only a few heavy rifle charges may do the trick. Once these lines of flow are established, the powder will measure at its maximum uniformity. The coarseness of the grains, the character of the grain surfaces and, to a lesser extent, the moisture in the atmosphere, will affect the uniformity of the flow; fine, smooth powders will always flow smoother and consequently measure more uniformly than those with coarse or rough grains and there is nothing that anyone can do about it— unless it is to weigh them.

To summarize: the proper way to adjust a powder measure is to put the powder in, filling the hopper or reservoir nearly to the top and then tap or jar the measure, settling the powder until it will settle no further. Then, with the cover off, throw enough charges rapidly into any suitable box or container so that a depression begins to form in the upper surface of the powder, over the measuring

cavity. It is immaterial whether the measuring cavity be adjusted before or after the powder is put in. The powder that has been taken from the measure in doing all this can be dumped in on top without affecting the charges.

It is commonly recommended that the powder measure be kept at least half full of powder so that the charges will be uniform and not be affected by the reduced or greater weight of the powder column. Well—that won't do a bit of harm, but is surprising how little difference the weight of the powder column makes with the charges thrown. With the lines of flow established, the charges will run uniform until the powder in the reservoir of the measure is nearly exhausted. Once the measure is in operation, loose powder added will not affect the charges, unless the powder level be very low. Try it sometime. In fact, if reloaders would do a bit of experimenting to see how *little* difference some things like this make, instead of letting their imagination run wild over theoretical details, they would load a lot more and better ammunition and get much more enjoyment out of doing it.

The Belding & Mull powder measure has two reservoirs and a detachable measuring device. The operation of the measure is such that when the operating lever is pushed over, a quantity of powder passes from the upper reservoir to the lower one and loose powder from the lower one flows into the measuring device. The powder available for charging the cartridge is always loose and it is claimed that this makes for greater uniformity of charges. It certainly provides a uniform condition from one charge to another and possibly offers some slight advantage as compared with the Bond and Ideal measures, provided these last mentioned measures are used improperly. I have used them all, and have used them correctly, and I honestly can see no advantage in any one over the others that is of practical consequence. As previously mentioned, one or the other of them may show a little better uniformity with certain charges and powders, but they are all equally good and I mean, good when they are used with proper care. Charges of some powders can be thrown with any of them to such close limits that there is absolutely no need of, nor advantage to be gained by using a scale. Scales are useful for setting any of these mechanical measures to throw *exactly* the charge desired, provided that the scales are as accurate as the measure. Scales are a necessity for weighing maximum charges, as these charges are dangerous in that they encroach considerably upon the factor of safety of arms and allow little or no leeway for ordinary variations on the plus side. There are so many other things that can cause pressures to rise besides the powder, that the use of maximum loads cannot be recommended; at least they should only be used by reloaders who know more about ammunition than just weighing powder charges to a small fraction of a grain. However, when these overloads *are* used it behooves one to use every care with the powder charges. That at least is one step in the right direction.

In operating a powder measure, one should be methodical. The handle should be raised and lowered uniformly, both as to the force employed and the time. This is not important with the Belding & Mull measure, but it is with the Ideal and Bond measures if one wishes to get the finest degree of accuracy that these measures are capable of. The little knocker on the Ideal measure should be flipped the same each time but it is immaterial whether it be flipped hard or easy, so long as it is done uniformly. Leave the operating lever down after throwing a charge. Time is a factor in the way that the powder settles in the measuring cavity and if this cavity is exposed to the powder in the reservoir for varying periods of time, the powder will settle a whisker more one time than another. If the handle is left down between charges, raised to the charging position and held there for about a second and the charge then emptied; and this procedure kept even and uniform, the best accuracy will be obtained. Naturally, the powder measure should be used on a table or bench that is free from vibration. Powder measures that are mounted on reloading presses cannot throw charges as uniformly as those that are divorced from any jar or vibration.

The moving parts of some measures will work very nicely if they are taken apart, oiled and as much of the oil as possible is wiped off with a dry cloth before they are put together again; but the use of oil cannot be recommended as a general rule. Often the dust and fine particles of powder will adhere to the oily surfaces, building up in streaks and causing the measure to stick. This will sometimes happen with a measure that has never seen any oil. The best remedy is to put a box under the drop tube to catch the powder, then work the lever up and down, forcing it if necessary, until it works freely. This working will polish the surface of the powder that has been caught between the moving surfaces of the measure and its presence will prevent the entrance of additional powder dust. The thin flake pistol powders are particular offenders in this respect.

Bridging. Bridging is a condition that may occur with any mechanical powder measure where the powder must pass through a drop tube before it enters the mouth of the cartridge case. It is obvious that any such tube must have an outlet orifice which is not larger than the caliber of the cartridge being loaded, although the opening may taper upward to a considerably larger diameter at the top. Sometimes, and especially with powders having coarse or long grains, the powder will drop from the measuring cavity in such a way that the grains will jam in the drop tube. This is known as “bridging” the grains; in effect, forming a bridge across the inside of the drop tube. When this happens, only part of the charge drops into the case whereupon the succeeding charge usually dislodges the bridged powder, causing an overload in the next cartridge. This is a condition which has to be guarded against very carefully in factory loaded ammunition, bridging being by no means limited to the mechanical powder measures used by hand-loaders.

It is therefore desirable to have the inside diameter of drop tubes as large as possible, so as to avoid this condition. The Ideal and Bond measures use drop tubes and as they are used for all calibers of cartridges, it would be necessary to have the exit orifices in these tubes small enough for ·22 caliber cartridges, if only one tube were available. Therefore, both manufacturers supply two different sizes; one handling ·22 to ·25 caliber cartridges and the other handling everything above ·25 caliber. Bond furnishes both tubes as standard equipment with their measure but Ideal only furnishes one; the standard or larger tube, if no caliber is specified. However, the smaller size will be furnished with the measure if requested. The operator should always use the largest possible size for the cartridge being charged. As the ·22 HiPower and many of the ·25 caliber cartridges utilize some of the coarse grained powders, special care is necessary to prevent bridging when loading these calibers —which is just one of the many reasons for inspecting *all* powder charges before seating bullets.

Drop tubes fit into a counter-bored hole, against a shoulder in the body of the measure, and are held in place by set-screws. The jarring due to operation of the measure, may and often does cause this screw to loosen, permitting the drop tube to work down a little. This makes a gap between the outlet of the measure proper and the top of the drop tube. The top edge of the drop tube is too narrow to form much of a resting place for grains of the coarser powders, but it will catch some of the fine grained ones. It is, therefore, advisable to check the drop tube once in a while to make sure it is firmly up against the shoulder in the measure and to be certain that the set-screw is holding it there tight.

The Ideal measure has a little swinging knocker on its front, which should be flipped up against the body of the measure to jar all the powder out of the tube, The Bond measure lacks this knocker, but the operating handle may be knocked against its stop several

times to accomplish the same result. Neither measure should be jarred when their handles are in the upward or charging position, as this cannot be done uniformly and will cause variations in the charges. Even with jarring, bridging will occur once in a while; also if the drop tube is not up into its seat fully the amount of fine grained powder that catches on top of it may not be dislodged completely each time.

The Belding and Mull powder measure uses no drop tube, but as the powder is fed into a separate charger so that the height of the charge is plainly visible before emptying it into the case, bridging is no factor in this measure. But drop tubes must be kept clean and clear and all measures watched closely in the interests of both accuracy and safety.

Factory Measuring Practices. Factory loaded cartridges are charged by three different means, all of which would be unsatisfactory without inspection of the charges after they are thrown.

One method is to "shake" the primed cases into a loading plate having a series of holes in rows, regularly spaced. This plate, filled with cases, is slid under the charger, the bottom of which is another plate with a similar series of holes bored on exactly the same centers as the plate holding the cases, these holes being beveled at the top. The upper holes are therefore directly over the mouths of the cases and are of a diameter smaller than the caliber of the cartridges being loaded, so that any powder falling through them will drop into the cases. On top of the upper plate is still another, with a similar series of holes on the same centers; this is the charging plate and it can be slid back and forth by means of a lever. The thickness of this charging plate and the size of its holes governs the volume of the powder charges. When this charging plate is slid to one side, its holes are off-set from those in the plate it slides on and their bottoms are closed by the solid metal between the holes in the lower plate.

In operation, the operator throws a scoop full of powder across the charging plate, employing a sweeping motion so that the top is covered with powder and all of the holes are filled, after which the excess powder is scraped off with a rubber edged scraper. In doing this, powder is scraped over any holes which were not filled with the first "swipe." The charging plate is then slid over the holes and those charges drop down into the cases, the operator striking the apparatus a couple of good raps with a mallet to jar all the powder out of the holes. Naturally, the corner holes do not get quite as dense a dose of powder as the holes in the center of the plate, but the operators of this type of loading machine become quite clever at throwing the powder and the variations in the weights of the charges are not great, although they would give heart failure to some of these theorists who can think only in tenths of a grain. In a loading machine of this type there is no opportunity for bridging of the powder, or at least the chances of a bridged charge are very slight. Nevertheless, the cases are inspected as they are passed on to the next operation. This method of charging cases is in common use for pistol and revolver charges and occasionally for some rifle cartridges.

Another method is to use a plate holding a smaller number of cases, 7 x 7 being a convenient arrangement of holes. These plates locate the mouths of the cases under a series of tubes leading down from the mechanical measuring device at the bottom of the powder hopper. The tubes originate from points in the charging mechanism which are more widely separated than the cartridge cases, so they are not all of the same length and some of them must curve considerably in carrying the powder charges to the cases. The operator of the machine uses a substantial mallet to rap the steel block in which the tubes terminate, to jar the powder out. When the plate of charged cases is taken from the machine, a jig or plate carrying a series of plungers, T shape in cross section, is placed over them so that a plunger will drop down into each case and rest upon its powder charge. The cases and plungers together are slid along to the next machine, but in so doing must pass through a template with profile cuts in it conforming roughly to the shapes of the plungers. The cross bar of the T in these plates is higher from top to bottom than the T heads of the plungers, so there can be a little variation in the heights of the charges and still let the cases and plungers pass through the slots. But if the variations in the height of even one charge in the block raises or lowers a plunger too much, the plate will not pass through the gate and the loading cannot be completed until the offending charge or charges are corrected. Beautifully shooting ammunition is loaded by this method every day in the week, which makes it look as if it wasn't altogether necessary to fool around with tenths of a grain to get good accuracy.

The third type of loading machine is the one most similar to the powder measures used by handloaders of ammunition. This type utilizes a cavity in a sliding block, or a rotating member with an adjustable measuring cavity, which successively charges from a hopper and discharges into a cartridge. All the charges are measured by the one cavity. These machines are always equipped with mechanical or electrical detectors for checking the heights of the charges after they are emptied into the cases, and some of them will automatically throw out cases which are over or under charged. There is naturally an appreciable tolerance in the heights of charges and the function of visual or mechanical inspection of charges is for safety only. The check for finer degrees of accuracy in charges is accomplished by taking charged cases from the machines at intervals and weighing their charges. It is common practice to weigh three charges at a time from each machine, and to take the average weight of those three charges as a check on the machine setting.

Any reloading tool or machine—past, present or future —that charges cartridge cases and which will not permit them to be inspected before the bullets are seated, is dangerous and not worth the powder to blow it to hell— no matter how ingenious it may be otherwise.

The Accuracy of Powder Charges.

Accuracy is a relative term. If we want to lie on our bellies and dump bullets into a ten inch bullseye two hundred yards away, our powder charges may vary as much as 5% in weight, without putting us out in the white and our ammunition is accurate. On the other hand, if we are in pursuit of the elusive one inch group at one hundred yards or the best accuracy we can get at a thousand yards, such a variation would make the ammunition inaccurate for our purpose. To generalize, pistol charges should be kept within a variation of 3% of the weight of the charge and rifle charges within 1%. These variations are satisfactory from a safety and accuracy standpoint, with charges up to and including normal full loads. If one is loading maximum charges, the variation should be kept as small as the Great Jehova and the Continental Congress will let it be. Mechanical measures, properly used, will keep most charges of powder well within the limits above mentioned but where the requirements are exacting an accurate scale or balance should be used.

Dip Measures.

The mechanical powder measures are by far the best for measuring any kind of powder charges with all the uniformity necessary for obtaining good accuracy. These measures are especially valuable for use with smokeless powders, as these powders are of such a

nature that anything more than small variations in the weights of charges may cause a considerable change in their behavior. This is particularly true with full loads for any cartridge, but the differences in burning caused by variations in the weights of charges decrease as the charges are reduced. One can have quite a little variation in the weights of reduced charges and still get pretty good accuracy up to two hundred yards or more and herein lies a boon to those who cannot afford to pay from seven and a half to ten dollars for a powder measure.

Dip measures are perfectly practical for measuring black powder, as in loading black powder, the case must be filled up to the base of the bullet. There is therefore, no chance of loading an over-load with a dip measure. These dip measures are also satisfactory for use with semi-smokeless powder, provided that the proper granulation of powder is used and the scoop holds the weight of charge recommended. Scoops are not ordinarily recommended for use with smokeless powders, as the variations in weights of charges that will be obtained with a scoop are sufficient to cause dangerous pressures if full loads are used. If, however, the load is enough below a full charge, scooping smokeless charges is permissible and, with care, good results can be obtained.

Belding & Mull or Lyman will, on special order, make up powder scoops to hold any specified charge of any kind of smokeless powder, or one can make one of these for himself if he has a scale available to check the charge measured by the scoop. A fired cartridge case, cut off or filed down so it will hold the proper amount of powder, with a wire handle soldered on is all that is necessary. In ordering a dip measure for smokeless powder, you should at least specify the kind of powder, that is, the manufacturers designation of it, and the weight of charge desired. It is also well to state the caliber of cartridge and weight and kind of bullet that will be used. These scoops are, for the most part, ordered by those with little or no experience with reloading and if all the information is given, the manufacturer may be able to set you straight if you have selected a powder unsuited for your purpose or an improper charge.

When you get one of these dip measures you will probably find the handle soldered onto the side about half way down; you can improve on this by re-soldering the handle near the top. This should also be done if you make your own dip measure. A combination of measure and dipping box that is very satisfactory and that will give you the most satisfactory and uniform results you can get with a dip measure can be made in the following manner:

Properly made dip measure and dipping box.

Solder the handle on the scoop near the top and in such a way that the little gap between the side of the cup and the handle, where the latter bends away from the cup, may be filled with solder. The placement of the handle should be such that a straight edge may be drawn along the handle and across the top edge of the cup without catching. A dipping box can be made from any suitable container; a tin baking powder or similar can, cut off so it is about two or two and a half inches deep will do. Now, solder a strip of brass across the inside of the can, near the top, so that the brass strip will form a chord of the circle of the top of the can. The strip must be at least the diameter of the dip measure away from the side. This completes the apparatus.

To use it, pour enough powder into the can so that the scoop may be passed through it and filled without touching the can. A good way to fill the scoop uniformly is to press its base down into the powder until the powder flows over the edges of the scoop, filling it. When the scoop is buried, raise it with the handle under the brass strip and draw the scoop toward you, scraping the powder off level with the top of the scoop. The slight jar of doing this may cause the powder to settle a trifle, but do not refill the scoop. What you want is uniform weights of charges, rather than uniform volume, and you won't get either if you do not do this dipping uniformly and systematically. You can dip charges much more uniformly with a box of this kind, than by holding the scoop in one hand and scraping it off level with a straight edge held in the other.

Some kind of a funnel will be needed to pour the powder into the cartridge cases. A convenient and inexpensive one made from a small aluminum funnel and a drop tube for a powder measure is described at the end of the section on "Powder Scales."

Loading Blocks.

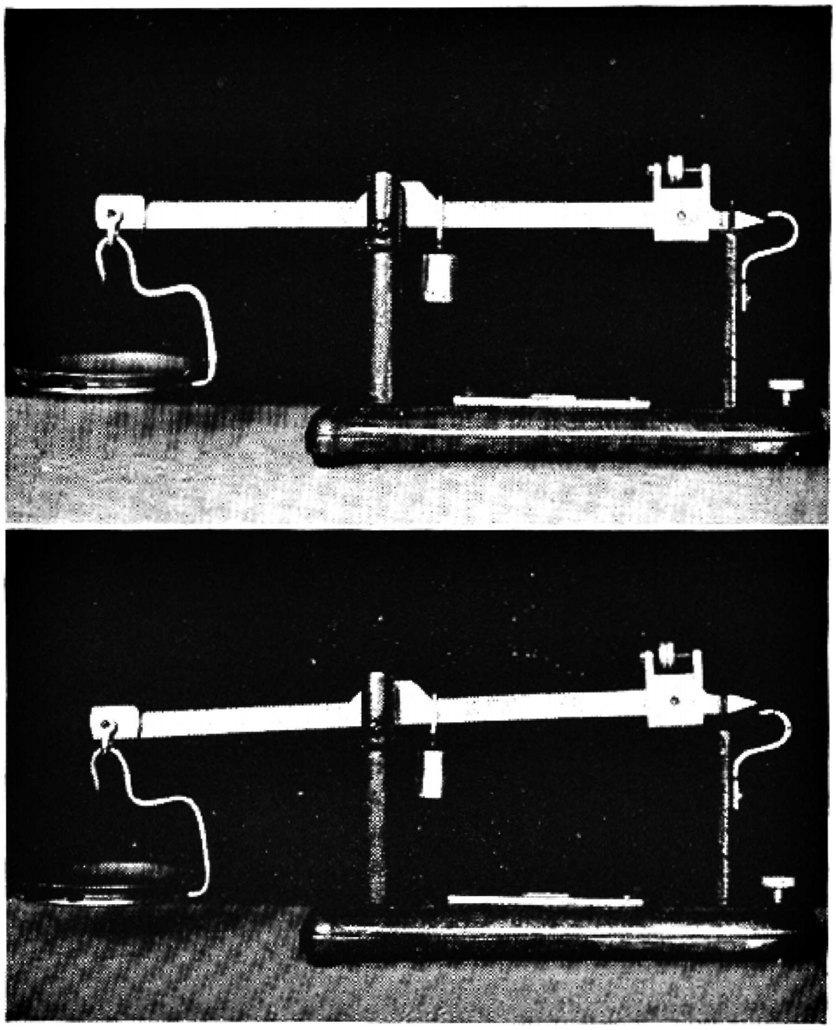
A loading block is a great convenience when charging cases, when charging them with smokeless powder it is almost a necessity. These loading blocks are merely blocks or boards with a series of holes bored nearly through them, so that the charged cases may be set in them without danger of their being knocked over. A loading block can be easily made by boring a series of holes through a board, then tacking or gluing another thin board to one side to form bottoms for the holes. The holes should be large enough in diameter to receive the heads of the cases easily. Loading blocks can be purchased from Bond or Belding & Mull if desired.

Bullets should never be seated in cases without first inspecting the charges. If charged cases are put into a loading block, the block can be tipped toward a good light, without danger of spilling the powder, and the heights of the charges observed. Having all the cases together in this way, any irregularity in the heights of charges will be observed at once, by comparison.

In the manufacture of commercial ammunition, electrical or mechanical gauges are employed to verify the heights of the powder charges before the bullets are seated and with some cartridges the powder charges are again checked after the ammunition is completed. This final verification of the charge is accomplished by weighing the complete cartridge. This weighing will not show up

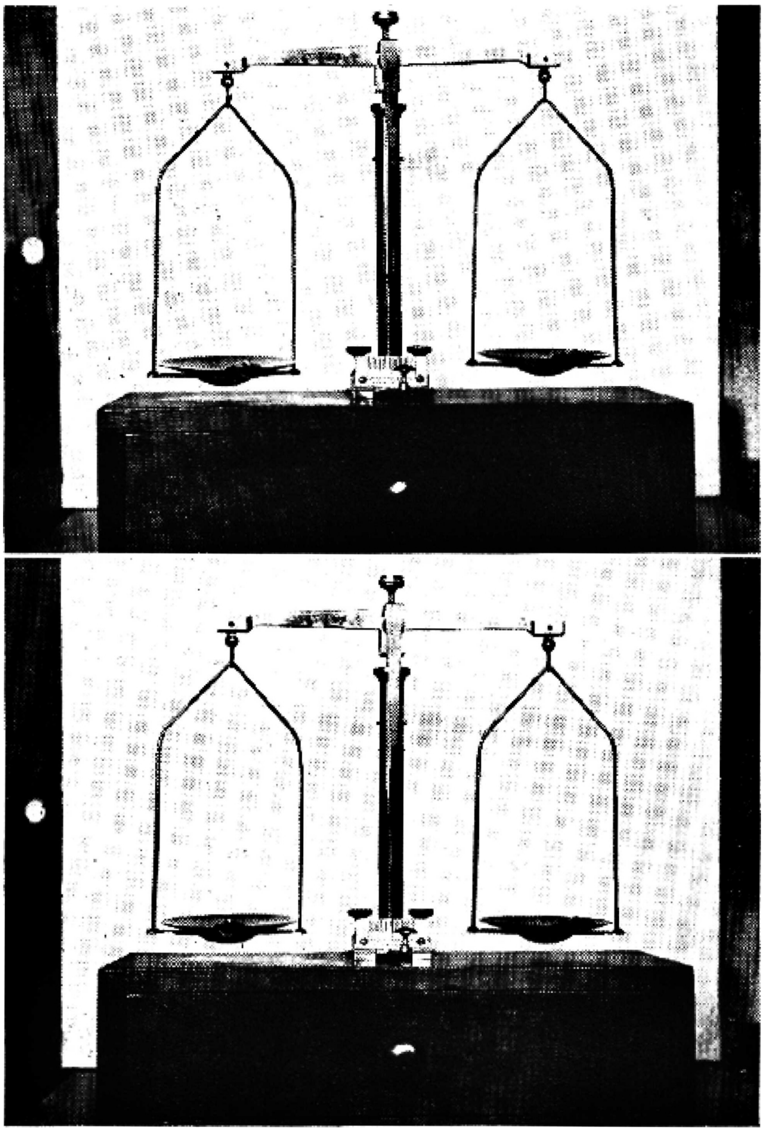
minor variations in charges, because of the variations in the weights of bullets and cartridge cases themselves, but it does serve to eliminate cartridges that are seriously overloaded.

Pistol and revolver cartridges cannot be checked by weighing, because the permissible variations in the weights of bullets and cases sometimes exceed the total weight of the powder charge. If the manufacturers of ammunition must take such pains to insure the safe loading of their ammunition, the handloader certainly cannot afford to be less careful. *Always* inspect your powder charges before seating bullets.



Illustrating poor sensitivity in a powder scale—a condition where the beam "sticks". Scale appears to be alright when charge is first weighed, but if scale pan is touched with the tip of a pencil it drops and will not return to original position. The only solution is to return such scales to the manufacturer for adjustment and correction.

PLATE XVII.



Illustrating proper condition of good sensitivity in a balance. Lower shows index pointer at zero despite efforts to throw it off. Upper view shows a one-tenth grain weight in one pan, which throws pointer off, yet it returns to same position every time. A scale or balance as accurate and responsive as this is suitable for use with maximum charges.

PLATE XVIII.

CHAPTER TEN

POWDER SCALES AND BALANCES.

A balance or scale that is reasonably sensitive is useful but not necessary for the loading of ammunition for all ordinary use. When the very finest long range accuracy is desired, or the ammunition is being loaded with over-charges of powder that develop pressures encroaching upon the margin of safety of the arm, a good scale becomes a necessity. There are a number of scales and balances selling at from seven to twenty dollars that are amply accurate for this purpose and, contrary to popular belief, they do not have to be sensitive to “a tenth of a grain.” Even though a scale has this degree of sensitivity, it is improbable that the average handloader can load a series of cartridges with such a small tolerance, and the idea that charges have to be accurate to this degree is pure hokum. I do not mean that it is not desirable to have powder charges as uniform as possible, nor that it would not be desirable to keep them uniform within this magic limit of one tenth of a grain; I merely state that such accuracy cannot be obtained with certainty, even *with* a scale sensitive to one tenth of a grain.

Now, in case there are some individuals disposed to rear up on their hind legs over such a heretical statement, let's look at the subject from an abstract standpoint, before going into the practical use of scales and balances. If you have a rifle and ammunition capable of shooting two inch groups at one hundred yards, you can't shoot possibles with it *all* the time, because it leaves nothing for the human error. Two inch groups and a two inch bullseye is just like putting a two inch plug into a two inch hole. (And there is some question as to whether that can be done.) On the other hand, if the rifle will shoot *one* inch groups, we can shoot possibles with it frequently enough to feel gratified and *sometimes* we will get groups of one inch or even less. The same principle holds true with powder scales. The human element plays just as great a part in weighing powder as it does in shooting, and there must be some leeway in the accuracy or sensitivity of the scales to take care of it. Furthermore, a scale that may have been sensitive to a tenth of a

grain when it left the factory may not be that when you get it and even if it is, it will not stay that way indefinitely. With the powder scales commonly used, it is possible to keep charges within *two* tenths of a grain all the time and within one tenth of a grain some of the time, provided the scale is in good condition, clean, and is used with care. Anyhow, two tenths of a grain is accurate enough.

Now let's look a bit closer at the practical side of this question. The accuracy of a scale or balance depends upon two things; its sensitivity and the accuracy of the weights used. The sensitivity is the ability of the scale to register small differences in weights with uniformity and precision. This depends upon a number of things, but by far the most important is the knife edge that supports the beam and the bearings upon which it rests. In the more expensive balances that are sensitive to from one hundredth to one thousandth of a grain, these knife edges are very sharp and rest upon bearings of agate or other hard substances, into which the edge cannot cut. Such balances are alright for laboratory use, but for the practical weighing of powder charges they are not worth a damn. They are so sensitive that it takes forever for them to come to rest. A person skilled in their use can weigh about two charges per minute and keep the charges within one tenth of a grain (?) but to weigh anything to the limits of accuracy of the balance would tax the patience of Job. Such balances are often mounted on cement bases that pass through and are entirely independent of the building in which they are located so as to be free from any vibration or jar. The normal breathing of a person will disturb them, and their accuracy is too great to be of practical value for weighing powder charges.

The scales and balances ordinarily used for weighing powder charges and costing up to twenty dollars, while crude in comparison, are much more practical and are amply accurate for the purpose. Their bearings are either of steel or iron, and the knife edges are not usually dead sharp but have just enough of the edge taken off so that they will not cut into the bearings.

In addition to the main bearing, there are bearings where the weight or weights are suspended. These must be free, for if they bind the least bit the sensitivity of the scale will be interfered with. The ends of the knife edges should not bear upon the end caps of the bearings and every precaution should be taken to see that all pivot points are free and that they oscillate easily.

Oil should not be used on the bearings of powder scales. The use of a small quantity of high grade watch oil may be justified at times, where climatic conditions are conducive to the formation of rust, but after its application, the oil should be wiped off completely. Dust is apt to accumulate in the bearings where it will impede the free movement of the beam of the scale. The presence of any oil will cause dust to stick, in addition to the possibility of the oil gumming which, in itself, is bad enough. A camel's hair brush is convenient for dusting the bearings. Don't blow on them, as the condensed moisture from your breath may promote rusting.

Leveling the Scale. The surface upon which a scale is placed and used should be as level as possible. Some scales and balances have levels mounted on them, by means of which they may be precisely leveled but in a class B or class C balance, such as are used for weighing powders, the absence of a level is not important. The instrument can be brought to balance by raising one end of the base slightly with strips of paper or cardboard, or a small metal level can be used if the upper surface of the base is smooth and flat. The important thing is to have the beam or pointer of the scale oscillate freely and come to rest at the zero point. If this is accomplished without leveling the base, it is important that the base be not moved while the scale is in use. Movement of the base may change its angle and throw the scale out of balance and if it should become moved, inadvertently or for a reason, the zero balance should be checked before any more powder charges are weighed.

Checking for Sensitivity. Most scales have some kind of an adjustable counterweight or rider, by means of which the balance can be brought to zero when the base is level. Such devices are useful on any scale but they are of special advantage on scales having levels incorporated in their bases. When the base is leveled and the counterweight is adjusted to zero on the beam, the scale will be in permanent adjustment and, whenever it is used, it will only be necessary to level the base in order to bring the beam to a zero balance. When the scale is set up, it should be checked for sensitivity. To do this, adjust the scale approximately for balance and when it is at rest, push the beam down carefully and see whether or not it comes up to the point it started from. Now, it doesn't take a crowbar or the weight of a finger to push the beam down, so to make a check that is worth anything, a good deal of care must be used. The point of a camel's hair brush or the tip of a well sharpened lead pencil applied delicately to the beam, near the knife edge, will serve, provided one has a delicate “touch.” I prefer the pencil. These tools, carefully used, are also a useful aid in bringing the beam to rest quickly when weighing powder charges. Try making the beam stay below center several times and if the beam always returns to its original position, reverse the process and try to make the beam stay above center. If the beam shows no tendency to “stick,” the scale is all right for sensitivity.

The two illustrations of a Fairbanks Assay scale shown give a graphic example of the result of such a check. It will be seen that in one picture the beam is stationary somewhat below the zero pointer, while in the other it is considerably above. In ordinary use, this scale will not show such a wide variation and it is proper to state that this scale is shown to demonstrate a particular condition and not as any indication that this model of scale is inaccurate. It may not be the best for the purpose of weighing powder charges, but it is plenty good enough.

By way of comparing the condition just referred to with one of good sensitivity, two pictures of a balance are shown. In one, the balance is at zero, after trying to throw it off one way or the other. No matter what was done, the index pointer would always settle down to zero. In the other picture the balance has a ·1 grain weight in one pan. The tip of the pointer can be seen as a dark mark, three graduations to the right, but actually it is not quite that far and only appears so because of the angle from which the picture was taken. However, the important thing is that, no matter how the beam is moved, it will return to the same original position. Any scale or balance that will not register the same every time with a 1/10 grain weight can hardly be expected to weigh powder charges with that degree of uniformity, no matter how carefully it is used.

Sticking of Beam. Sometimes a scale will develop a pernicious habit of sticking. More and more powder is put onto the pan with no movement of the beam until, suddenly it bobs up to its highest position and a very appreciable quantity of powder has to be removed to bring the scale to balance. Then again, adding powder, a few grains at a time, may bring the scale gradually to the zero point of balance, but if a little pressure is applied to the side of the beam from which the powder is suspended, it will be found that the charge is heavier than was supposed. All of which means that the real weight of the powder charge may be different from what the scale says it is. When a scale behaves in this way with the knife edge and bearings clean, the best bet is to return it to the manufacturer (not the dealer you bought it from) for adjustment. This assumes that the scale is one of a good enough grade to register tenths of a grain when in good condition. Where there is a tendency to stick, or a lack of sensitivity, no artificial means of bringing the scale beam to rest should be used. On the contrary, the beam should be set in motion several times to see whether or not it will come to rest at about the same point each time.

Use of Scale for Setting Powder Measure.

This is the most common use for a powder scale. To use it efficiently and set the measure quickly and accurately, the latter should first be set according to the table appropriate for it and operated a few times to settle the powder and establish the lines of flow. Then set the scale to weigh *five times* the weight of the charge you desire. Measure out five charges and put the powder on the pan of the scale. Add or take off weights to determine the error, then adjust the measure for one fifth the error, repeating the process until the weight of five charges is correct.

Working with only one charge at a time is likely to be tedious work and result in many unnecessary changes in the setting of the measure. Some fine grained powders will measure so accurately and uniformly through a mechanical powder measure that there is nothing to be gained by weighing them, but the coarser grained powders will show some variation from charge to charge. These variations are not greater than those found in factory loaded ammunition, nor are they sufficient to cause dangerous pressures in normal charges. But as far as the powder measure is concerned, it can only be adjusted to throw an *average* charge that is correct. It is well to place the scales close to the measure and to check the latter from time to time, but in doing this follow the procedure of weighing five charges or, for that matter, any number that will give an average result.

When measuring charges with a mechanical measure, the scale supplements the measure, but when weighing them the situation is reversed and the measure may be used to supplement the scale. For weighed charges, adjust the measure to throw a charge slightly under the desired weight. Throw the charge onto the pan of the scale and, by hand, add the few grains of powder necessary to bring the beam to balance.

Fairbanks Assay Scale. This scale has long been a stand-by for weighing powder charges and it is satisfactory for the purpose. I believe that its popularity is due to the fact that it was at one time about the only scale available for the purpose. It has a level in the base, with an adjustable screw support at one end of the base for leveling. The beam is provided with an adjustable counterweight for zeroing the balance of the beam when the base is level.

The beam itself is notched on both sides of the knife edge and carries two permanently attached weights, the small weight on one side weighing up to five grains, by tenths of a grain, and the large weight being adjustable in five grain increments. This feature has been much touted as an advantage and it is true that the weights cannot become lost, but the advantage of a notched beam is questionable where exact weights are desired. In the first place, there is a limit to the accuracy with which these notches can be cut. Such variation as there is does not amount to anything on the tenth grain notches, but if the scale be checked with a set of accurate weights it will be found that the five grain notches are sometimes a tenth of a grain or more off. These errors are of no practical importance and they are not cumulative, that is, they do not increase as the weight is moved along the beam. They merely occur in some notches and not in others. Due to tool marks in the notches and to the presence of unpolished plating, the hanging weights sometimes catch on a minute projection or rough spot and do not hang at the very bottom of the groove they are in. This is not a common occurrence, but it should be watched for when setting the scale. However, it is a good powder scale for general usage and its sensitivity is not great enough to prevent the beam from coming to rest quickly.

Pacific Scale. This scale is somewhat similar in appearance to the Frankbanks, but is entirely different in principle. It has no level nor means of leveling and it does not have to be adjusted for balance without weights on the pan. To use it, the scale is placed upon the table and weights to the extent of the weight of powder charge desired are put on the pan. The scale is then brought to balance by means of a threaded nut and lock nut on the beam, after which the weights are removed. When the amount of powder in the pan is correct to balance the beam, the weight of the charge will be the same as that of the weights used to adjust the scale. As long as the original position of the *base* is not changed, the scale will weigh charges accurately. If the base is moved, the balance of the scale should be checked as when first adjusting it.

This is a low priced scale, but a good one. The knife edges are one piece and are stiff and rigid, being formed on a flat steel plate that is locked against a square shoulder on the beam. There is little chance of their getting out of alignment. The bearings are round and of steel so that, theoretically, the knife edges rest on points. In theory, this is bad design but in this case it works O. K.

Some of these Pacific scales have a little paint on the bearings when they come from the factory and this should be removed if present. Care should also be taken to see that the knife edges are in the center of the bearings and that there is no interference between them and the grooves in which they are set.

Bond No. 80 Scale. This is in reality a Brown & Sharp yarn scale. It is a sensitive and accurate scale, well adapted for weighing powder charges. The base is provided with a level and means for leveling, and as this scale is correctly adjusted at the factory, no counter weight for balancing is necessary. Should the scale get slightly out of adjustment and fail to balance exactly with the base level, the adjusting screw may be used to bring the beam to balance without reference to the level in the base. The beam is graduated to twenty grains by tenths of a grain and *is* provided with a small sliding weight. A set of weights are provided for weighing quantities in excess of twenty grains and they are in such denominations as will permit any quantity to be weighed in increments of tenths of a grain, up to the limit of the scale. The writer has used this type of scale for many years in figuring costs of woven fabrics, as well as for weighing powder, and has found only one minor fault with it. The sliding weight on the beam is not fixed in its position and the jar incident to removing and replacing the pan will often cause it to move. It is necessary to keep an eye on it and see that it is kept in the correct position when weighing charges, but as this can be done almost without conscious effort, it cannot be considered as a fault.

BALANCES.

Where the greatest accuracy is desired, I consider a good balance superior to a good scale. Balances are commonly graded as grades A, B, and C. Grade A balances are expensive, their extreme sensitivity makes them slow to use, and they will not develop their full accuracy except in the hands of a person experienced in their use. They can be classed as unsatisfactory for the practical loading of ammunition. This may sound like a strange thing to say; it will probably only be taken at its face value by those who have breathed in short gasps or held their breath most of an afternoon while trying to weigh a dozen or so charges on one of them.

Class C balances have a sensibility reciprocal of from 1/4 to 1/8 grain and they are satisfactory for weighing all but maximum charges.

This leaves the Class B balances, which are really the ones best adapted for weighing powder charges. They are amply sensitive, but as a rule slower to use than a scale. They can be obtained at a moderate price, varying from about fifteen to twenty dollars, and of a sensitivity of 1/10 grain. The No. 010 and 991 balances made by Henry Troemner of Philadelphia, one of the best known manufacturers of scales and balances in the country, are much used and can unhesitatingly be recommended for the weighing of powder charges.

Weighing Accessories and Gadgets. There are a number of ways in which a handloader can improvise little gadgets that will help to keep his scale or balance in good condition, or even to improve its usefulness. I do not mean by this that he can or should attempt any amateur blacksmithing on the scales themselves but there are a number of accessories which any handy man can make.

As the bearing of a scale is the very seat of its sensitivity, every precaution should be taken to keep this bearing or knife edge in perfect condition. If the scale is not to be used for some time, it is best to dismount the beam, thus taking the weight off from the knife edges. Balances are usually provided with a lever by means of which the bearing may be raised or lowered, but even in the lower position the weight is not always taken off the knife edge. Pieces of cardboard of suitable thickness can be placed under the hangers, so that with the bearing in its lowest position the beam will be relieved of the weight of the hangers and pans.

If the scale has a permanent place of abode and is not taken down and stowed away after each use, it is a good plan to protect it from dust. The better grades of balances are supplied with glass cases, the front of which can be slid up to open when the balance is being used, a counterweight or catch holding it open. This is a very nice and convenient arrangement, but the less fortunate brethren can keep just about as much dust off their scales by inverting a cardboard box over them. Of course the cardboard box can be elaborated on, and a person handy with tools can make a very creditable case of ply wood, or even of glass, at very small expense. Such a case may not be absolutely dust proof but it will keep the greater part of the dust off.

The shallow pans with which most scales and balances are equipped are not very convenient for pouring powder out of, once a charge has been weighed. As a matter of fact, they are so shallow that in pouring any of the coarser grained powders onto them, some of the kernels are likely to bounce off. When using such pans, a funnel must be employed to pour the charge into a cartridge case. One can be rolled out from a sheet of heavy bond paper but a much better one can be made from a small seamless aluminum funnel and a drop tube from a powder measure. These aluminum funnels can be obtained from any department or five and ten cent store, and a powder measure drop tube from any of the loading tool manufacturers. The spout or outlet of the funnel can be forced into the upper tapered end of the drop tube, and there you are. The drop tube can be placed over the mouth of the case and the powder poured into the funnel from the scale pan without danger of spilling any.

Where balances are being used regularly for weighing powder charges, they are often equipped with a scuttle or bucket-like aluminum pan, with a spout which permits the powder to be poured directly from the pan into the cartridge case. This is a great convenience and the handloader can improvise something of the kind from light sheet metal. If he is real clever, he can make it to fit the hanger of the balance and thereby eliminate the weight of the regular pan, but otherwise it will have to be placed on the pan, in which event a tare or counterweight of equal weight will have to be made for the other pan, in order to offset the added weight of the bucket. The counter weights provided for the normal balancing of the beam will be entirely inadequate for this purpose. The tare weight can be made from any piece of metal filed down so as to make it exactly the proper weight. Regular scale weights should not be used for this purpose, as they may become confused with those representing the weight of the powder charge.

The bucket should be kept as light in weight as possible, thin sheet brass or copper being used in making it. Aluminum is better still but it cannot be readily soldered. An aluminum sugar scoop, which can be purchased in almost any store, contains an ample amount of metal for the making of such a bucket. Aluminum is soft and easily cut or bent, but the seams will have to be filled with liquid solder in the absence of special aluminum solder, for there must be no folds or seams in which fine grained powders may become caught. The metal left for the spout should be wide enough to fold completely over with the edges butted together, so as to form a tube small enough for its end to be entered in the cartridge case. This isn't as much of a job as it sounds; with a small hammer, a pair of scissors and a file, a very creditable piece of work can be turned out.

Incidentally, one of these small aluminum scoops, just as it comes from the store, is very handy for pouring powder back into the canister when one has finished with it. It is only necessary to squeeze the mouth of the scoop down narrow, then close its top edges over with the fingers. Powder from the measure or the box from which it was being dipped can be dumped into the scoop and then poured directly into the canister.

CHAPTER ELEVEN

HANDLOADING VS. BALLISTICS.

It is customary in any work on the subject of hand-loading ammunition to describe and discuss the various types and makes of loading tools which are on the market. This will not be done in this book for two reasons. In the first place, all one can do in a discussion of these tools is to express opinions and point out faults or virtues, or at least those things which the particular writer considers as faults and virtues. After all, these are but personal opinions and they oftentimes create an idea in the mind of the reader that one particular tool is infinitely superior to another, or possesses certain advantages in some of its features. These opinions, and the impressions created by them, oftentimes work to the disadvantage of some particular manufacturer, even though they are not intended to do so.

As a matter of fact, any of the loading tools now on the market, with one exception, will load safe and accurate ammunition if they are used intelligently and with careful thought as to what must be accomplished in the finished ammunition. This does not mean that the best results will be obtained by using the tools in accordance with the simple directions furnished by the manufacturers, even though these directions may be adequate for the loading of pretty good ammunition.

As new loading tools make their appearance on the market, they are usually written up and described by the gun editors of the various shooting publications and while, for the most part, an earnest attempt is made to describe such tools faithfully and to give an

honest opinion regarding them, these opinions are of necessity based upon a limited use or examination of the machines referred to. This is only natural, but there is another aspect to such write-ups which is unfortunate, for one occasionally reads a glowing description of a loading tool or machine when it takes only a glance at the apparatus to see that it is of faulty design in many respects. When reading these effusive accounts one is forced to the conclusion that the tool written about was either given to the editor, who was thereby under obligation to the manufacturer to pay for it by saying some nice things, if possible; or, that the writer had an extremely limited knowledge of the subject.

The machine referred to above, as being one exception to those on the market which will load safe and satisfactory ammunition, is a case in point. This machine, when it first came out, was written of in most glowing terms. I am not going to give its name, nor describe it in any such detail which might serve to identify it. It is an excellent mechanical job and of ingenious design and I understand that there are a number of them in use that are giving results at least satisfactory to those who are using them. Suffice it to say that when this machine was placed before the writer, he took one look at it and refused to waste his time in any further playing with it. Shortly thereafter the gentleman who did try the machine out thoroughly, and who incidentally is experienced in the loading of ammunition, blew up a gun with the ammunition produced by it.

I am afraid some firms that are manufacturing loading tools have, for the most part, studied the loading of ammunition only superficially, if at all, and that they are more concerned with turning out tools and machines that will make things which look like cartridges than in considering the effects produced on the cartridge by the various appliances and attachments of the loading device. If the newer loading tools have a fault, it is in this confounded effort to combine operations and thereby load ammunition more rapidly. In reloading ammunition, or in manufacturing it, speed of production is always a secondary consideration. Safety is of primary importance and it is dependent largely, if not entirely, upon proper inspection—on the subject of which a considerable amount of space has already been given throughout this book.

It is true that some ammunition manufacturing and loading machinery performs a series of operations without permitting hand gauging or visual inspection of the work. BUT—all such machines are equipped with mechanical or electrical devices which perform the proper inspection necessary to insure the safety and quality of the finished product. These inspection or gauging devices are not depended upon to perform their functions unfailingly. They are subjected to continuous tests and checks by the operator of the machine, who frequently inserts cartridges or components containing the defects that the detectors are supposed to pick out, to make sure that the apparatus is functioning perfectly. The moment one of these defective cartridges or components passes its detector, the machine is shut down and a machine setter is called to make the proper adjustments. Then, of course, there is always the foreman who is around to make sure that the operator uses the defective samples with sufficient frequency. This is vastly different from a loading tool that perfunctorily performs a series of operations without consideration of the quality of product which comes out of the other end of the machine.

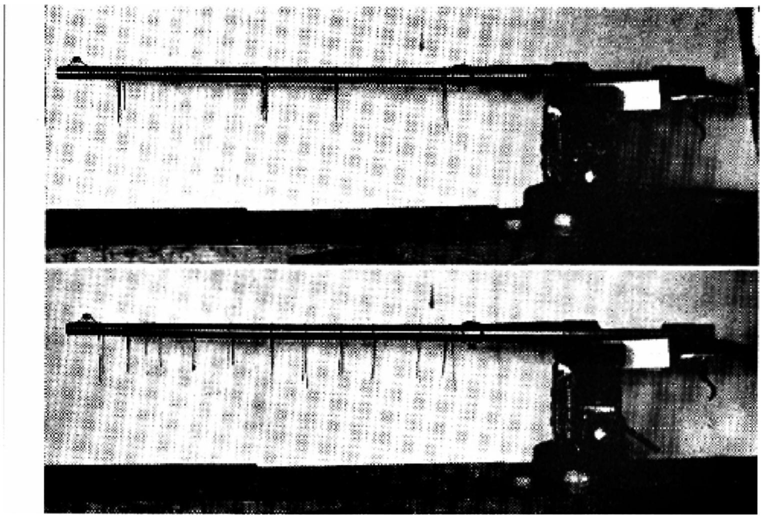
It is not to be understood from these remarks that any tool which combines loading operations isn't any good for, even though the combination of operations is unwise, it is usually possible for the operator of the tool to separate the operations and perform them one at a time. A simple example of this is the combining of the operation of expelling fired primers and the seating of new ones. This is not practical, is prejudicial to the best accuracy in ammunition, and with heavy loads may actually be unsafe. Yet it would be unwise to condemn any reloading tool, merely because it combines these two operations, provided the design of the tool will permit the operator to separate them. Principally for these reasons, the different makes of tools will not be referred to or compared, but rather the process of loading will be viewed and discussed in the light of the results which must be accomplished. In this way the text will serve for use with any type of loading tool—past, present or future. The loading of good ammunition is more of a ballistic problem than a mechanical one and it is the ballistic phase that manufacturers and designers of loading tools apparently ignore.

In order to tie in the performance and use of loading tools to this ballistic phase of handloading, the general subject of ballistics will first be briefly discussed, then the sequence of events that take place when a firearm is discharged. The rifle will be used as a basis for a description of the loading of ammunition, after which the peculiar problems relating to the revolver and automatic arms will be given.

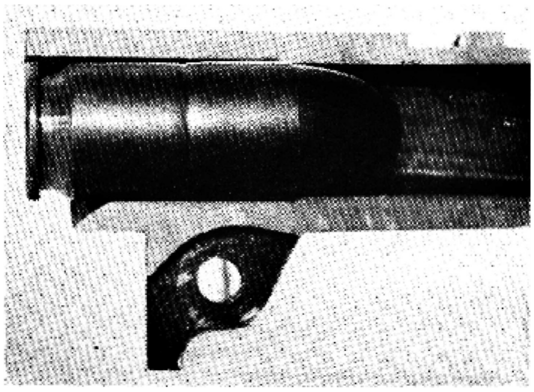
Some of this may be a duplication of what has already been written in other parts of the book, though from a different viewpoint, but it is necessary to consider this sequence of events chronologically, even though some of them may have been referred to in considering the performance of various ammunition components.

The science of ballistics is an interesting one to most shooters but it is not the purpose of this book to go into the theoretical or mathematical side of the subject, rather, to stick to the practical aspects. As a matter of fact, mathematical ballistic calculations are about as useful to the hand-loader as the proverbial silk pajamas are to an Eskimo, because the application of practically all ballistic formulae are dependent upon definite numerical values which can only be obtained with the facilities of a ballistic laboratory.

For example, the muzzle velocity of any given cartridge, as printed on the cartridge box or in the ballistic tables of the manufacturer, cannot be used as the basis for any calculations because these figures cannot be depended upon to be correct. This is due largely to changes that are necessary in the loading of the ammunition when changing from one lot of powder to another. The same thing holds true of pressures and such pressure figures as are published in tables of charges based upon the results obtained with one load of cartridges in one gun.

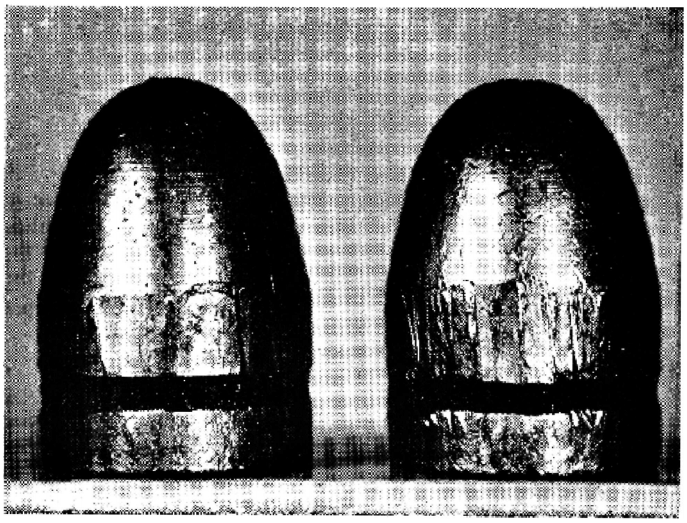


Barrel Vibrations.
Stripped barrel and action in lower view shows wires strung evenly along the barrel. By tapping receiver tang with a mallet, the wires are moved about by the barrel vibrations and group themselves at the nodes—as shown in upper view.

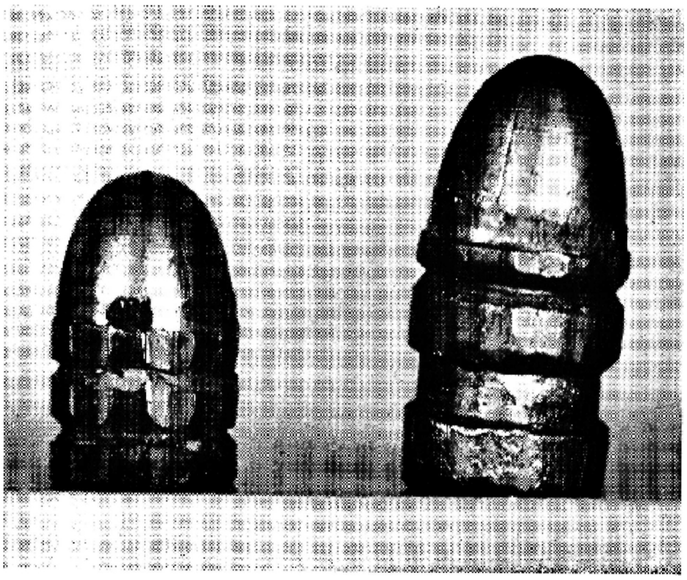


Illustrating the manner in which the ·45 Automatic cartridge is positioned and held in the chamber of the service pistol.

PLATE XIX.



Bullets which skidded.
A couple of bullets that never did get rotated properly by the rifling. Too soft and too short for the powder charges used.



Gas Cutting.
The bullet on the left was fired through a barrel with deep grooves. The one on the right through an oversize barrel. Note how the gas, rushing past both, has carried the edges of the bands away or rounded them.

PLATE XX.

As a concrete example of the variations in the performance of different loads of ammunition we can consider the cal. ·30-06 M1 cartridge, which is the present standard rifle and machine gun cartridge in the United States army. The standard average instrumental velocity of this cartridge is prescribed in specifications as 2640 f.s., plus or minus a small tolerance. For tactical reasons this velocity must be maintained from one lot of ammunition to another to a much higher degree of uniformity than is necessary in any commercial sporting cartridge. Yet every experienced rifleman knows that different lots of this ammunition may require a considerable difference in sight settings, especially at the longer ranges. Therefore, the handloader should judge his ammunition from the view point of actual performance, rather than by fooling around with any mechanical computations.

Another example which will show that mechanical computations give only an approximate result, can be found in the firing of seacoast cannon. The range finding and load data for every shot fired out of one of these big guns is a matter of permanent record. Furthermore, there is provision for fastening two pressure gauges in the mushroom heads of the breech blocks of these guns so that the actual chamber pressures developed can be measured, and the powder charges adjusted properly before commencing any range firing. In spite of these complete records and the duplication of charges that have been fired in the gun before, it is not uncommon for the first shots fired at a target to be as much as a thousand yards or more over or short of the target, necessitating an arbitrary correction in order to place the shots in the vicinity of the target—and this without any error on the part of the range or loading details. Therefore, we are going to be very practical in treating the subject of ballistics and leave the theoretical aspects to the text books, where they properly belong.

The subject of ballistics is divided into two parts: interior ballistics, which concerns the time between which the trigger of a firearm is pulled and the bullet is far enough out of the muzzle of the gun so that it is no longer affected by the expanding gasses; and exterior ballistics, which has to do with the free movement of the bullet or projectile through the atmosphere.

Interior Ballistics.

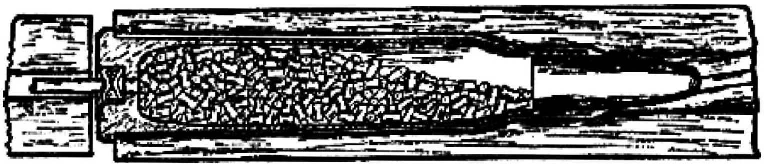
Interior ballistics, as related to small arms, is divided into four distinct phases. The first is the interval between the time the sear is released and the firing pin impresses itself into the primer sufficiently to promote ignition of the latter. The second phase represents the time required for the primer to transmit its flash to the powder charge and ignite a sufficient amount of it to promote combustion of the remainder. The third is the interval between the time the powder begins to burn, and transform into gasses, and the time that the bullet starts to move forward. The fourth and last phase is the time between the initial movement of the bullet and the time that the bullet is out of the muzzle and beyond the effect of the expanding powder gasses behind it. With proper facilities, these several time elements can be calculated or estimated, it being necessary to measure such intervals in units of one ten-thousandth of a second—a time measurement that is too small for human conception. However, the time of each of these phases will differ considerably in different cartridges, and will change with any change in the components of the loading of any cartridge- Therefore, there is no use in even attempting to suggest what these time intervals might be in handloaded cartridges.

The entire sequence of events, as mentioned above, is ordinarily referred to as the barrel time, although the true barrel time is more correctly that between the instant at which fire is produced in the primer and the bullet has left the muzzle of the gun. The time between the releasing of the sear and the production of fire in the primer is the lock time and has nothing to do with our handloading problem.

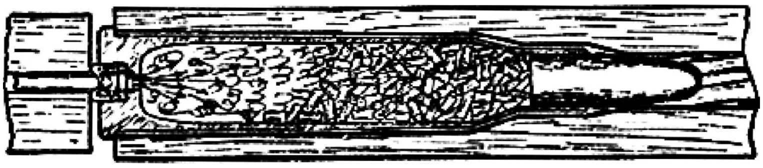
When a primer is struck by a firing pin with sufficient force to indent it appreciably, the priming pellet is pinched against the anvil and a flame is produced which passes through the vent or flash hole (sometimes more than one) in the bottom of the primer pocket and into the body of the cartridge case, where the propelling charge is located. This flame normally ignites more or less of the charge, which begins to burn at atmospheric pressure just as powder burns in the open air when ignited with a match. As the first grains of powder begin to burn, gas is given off which can find no escape from the closed chamber and as the volume of gas continues to

increase, the pressure rises. This first evolution of gas is known as "new" or "young" gas and as it develops, and the pressure rises, the walls of the cartridge case are expanded and pressed against the walls of the chamber—the neck of the case sharing in this expansion. The bullet has not yet begun to move and, with the neck of the case expanded, the new gas rushes past the bullet, escaping out of the barrel ahead of it.

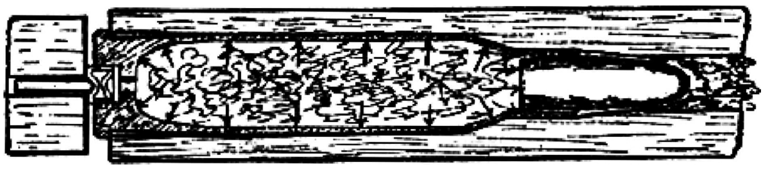
It is a well known physical fact that motion cannot be produced except at the expense of time and, therefore, the bullet does not move immediately, as its inertia must first be overcome. Now, possibly the reader has seen either in the moving pictures, or in magazines, extremely slow motion pictures of a golfer driving a golf ball. The ball does not move off the tee immediately when the face of the club comes in contact with it but proceeds to flatten out under the impact in a dough-like manner, shortly moving forward—still in contact with the club—gradually resuming its original spherical form and leaving the club due to its elasticity and the force of the blow imparted to it.



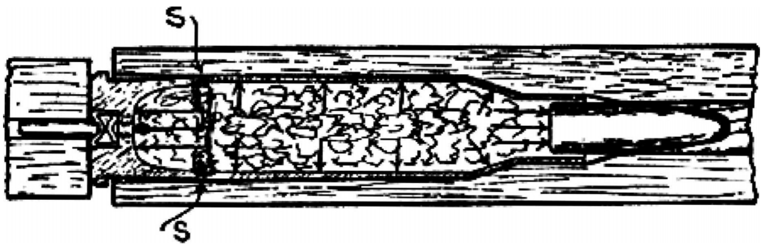
Firing pin has just struck primer, driving cartridge case forward and seating the rim of cartridge against back of barrel. Note clearance between cartridge and chamber, (exaggerated for purpose of illustrating what happens,) also headspace between head of cartridge and face of bolt.



Primer explodes, igniting the powder. Extremely violent action of the primer compound drives the primer partly out of case and back against breech block, also drives powder grains forward against base of bullet.



Powder burns almost instantaneously, developing pressure of from 30,000 to 50,000 pounds per square inch. This pressure expands the thin forward part of cartridge case against the walls of chamber, but cannot expand the thick part near cartridge head. Hence front part of cartridge grips walls of chamber tightly, while extreme rear part does not. Neck of cartridge case expands and gas escapes around bullet before it starts to move.



Bullet moves forward, sealing the bore as it does so. Back end of cartridge moves to the rear until it comes against breech block, while front part of cartridge remains locked in place by pressure of gas holding it against chamber walls. Cartridge stretches at S and may rupture if headspace is excessive.

DETAILED ACTION OF RIFLE CARTRIDGE IN FIRING

A somewhat similar condition occurs with a flat base bullet. With the passage of time, and the continually increasing gas pressure behind it, the bullet begins to move. But it does not all move at the same time, the base being the first part affected and moving independently of the point. This is not difficult to comprehend if you think of a bullet being fired against a hard surface, in which case the point of the bullet stops first while the base continues to move, causing more or less flattening of the point end or even complete disintegration of the bullet. A reverse condition takes place upon the initial movement of the bullet forward into the barrel. The base is moved first, and expands, and this degree of expansion is very considerable, even with flat base bullets having stiff jackets. The actual degree of expansion is limited only by the space available within the limits of the barrel and chamber. But finally the point of the bullet also begins to move and the bullet goes forward into the throat of the rifling, whereupon the escape of gas past the bullet is to all intents and purposes checked. The effort of the base to move faster than the point of the bullet may continue while the bullet is traveling as much as two or three inches or more along the barrel, by which time the entire mass will have obtained the same velocity.

This expansion of bullet bases is easily proven by sawing off the barrel just ahead of the chamber, firing a cartridge in it and recovering the bullet. The degree of expansion will naturally depend upon the hardness of the bullet and the force that is applied to it.

Barrel Vibrations. The disturbance caused by the blow of the firing pin, the sudden expansion of gasses in the chamber, plus the shock of the bullet moving up against the throat in the barrel, sets up violent vibrations throughout the length of the barrel. These vibrations are divided into two distinct parts, one of which is a whip-like motion of the barrel and the other a true vibration such as occurs, for example, in the string of an instrument when it is picked. These vibrations have a very material effect upon the performance of the arm. If they are uniform from one shot to another, the rifle will shoot accurately, but if anything is done to disturb their uniformity, which incidentally can be effected by improper stocking, they may not be uniform from one shot to another and there will be a considerable dispersion, no matter how accurate the ammunition itself may be, nor how accurately the barrel may be bored, rifled and chambered.

The vibration of a barrel causes a very considerable angular movement of the muzzle and while this movement might be in any direction across a circle whose center is the center of the barrel, a barrel will almost always vibrate more or less in a vertical plane. This is natural and logical, because there is a certain amount of “droop” in a rifle barrel due to its length and weight. In a long, heavy cannon, the “droop” may amount to as much as a couple of inches, although it is, of course, only a very small amount in a rifle barrel. Nevertheless, when an arm is fired, the first tendency of the vibration is to overcome the “droop” so the barrel moves abruptly in an upward direction, a movement which is ordinarily referred to as “jump.” The angle of departure of the bullet is the angle at which the barrel is elevated, plus the jump, plus or minus any angular movement of the muzzle itself due to vibration, at the instant that the bullet leaves.

Recoil. At the same time the barrel vibrations start, recoil commences, the recoil being the “equal and opposite reaction” to the movement of the bullet. The heavier the bullet or the higher its velocity, the greater the recoil is. In addition to the recoil induced by the movement of the bullet, which is known as the primary recoil, there is a secondary recoil which is caused by the column of gas issuing from, the muzzle and coming in contact with the resistance of the atmosphere. As this secondary recoil does not take place until after the bullet has left the muzzle, it has no effect on the angle of departure. The primary recoil does.

A rifle or pistol is normally supported below the line of recoil, the latter being coincident with the axis of the bore, and the effect of the recoil (other than that of unpleasantness to the shooter) is to cause the arm to rotate or attempt to rotate around the point of support. This causes the barrel to climb and move upward while the bullet is traveling through it and while the barrel is in a state of vibration. The movement of the barrel in recoil should not be confused with its movement due to vibration, when considering problems affecting them, but when shooting it is their combined action that governs the true angle of departure of the bullet.

The greater the recoil, the more the barrel will climb before the bullet gets out, provided that the barrel time is not reduced at the same time. If the velocity of the bullet is increased above normal while it is passing through the bore, it will leave the muzzle before the barrel has had time to climb as far as it might with a lighter load developing less recoil. But this is getting off the track and the point I wish to make here is that the barrel vibrates regardless of the amount of climb or jump from recoil and plays an important part in the accuracy that is developed on the target by the ammunition.

The general idea of barrel vibration can be seen clearly by means of a simple experiment which anyone can make. While it is not recommended that anyone remove the barrel and action of a rifle from its stock in order to try this experiment, nevertheless, the effect and violence of barrel vibrations can be seen by clamping the receiver of a rifle with only the barrel attached to it in a heavy vise bolted to a firm beach. If a “U” shape wire is hung over the muzzle of the barrel and the tang of the receiver is struck a moderate blow with a stick or raw-hide mallet, the wire will jump upward for an appreciable distance and may jump off the muzzle of the gun, and this with the receiver clamped tightly in a vise. If a number of these “U” shaped wires are hung at regular intervals along the barrel arid the tang is tapped repeatedly with light blows, the wires will move along the barrel and group themselves at the nodes on it. As most barrels are tapered and the nodes are closer together in the heavier parts of the barrel than in the lighter, thinner parts, the separation of the spacers will not be uniform. The illustrations given on Plate XIX show the effects of barrel vibration, one picture showing the spacers arranged along the barrel and the other showing the same barrel after the tang of its receiver had been tapped a number of times without touching the spacers in any way.

The vibrations in the barrel of any well stocked rifle will be quite uniform from one shot to another as long as the ammunition is uniform, but if the ammunition is not uniform for any reason, whether it be from appreciable errors in the powder charge, variations in the weights of bullets, faulty ignition (whether from poor primers, primers which are not properly seated, or dirty primer pockets), mixed lots of cartridge cases of varying capacity, or a number of other causes, the angle of departure of the bullets will not be exactly the same from one shot to another.

The writer was once told that the subject of barrel vibration had nothing to do with handloaded ammunition. Perhaps it hasn't, but the handloading of ammunition has a lot to do with barrel vibration and if the barrel vibration is not reasonably uniform, the results obtained with the ammunition will be unsatisfactory.

Heavy barrels do not vibrate as much as light barrels and the vibrations will be more uniform from one shot to another because of the lesser disturbance of the barrel; the heavy barrel is not as susceptible to small differences that exist from one cartridge to another in the ammunition. It is for this reason that heavy barrels shoot more consistently than light ones, rather than due to any special perfection in the rifling or chambering. A take-down rifle will not shoot as consistently as one with a solid frame, because of the looseness of the attachment between the barrel and the receiver, due to the take-down feature. Even though one of these arms may shoot quite well when new, it may change its center of impact considerably if taken down and put together again, and if frequently taken down the wear on the interrupted threads on the barrel and in the receiver ring will cause it to become less and less consistent in its shooting or we may say, less and less accurate.

If the bare barrel of a rifle is resting on any solid object, against the side of a tree, for example, when it is fired the arm will be thrown away from the point of support by the vibrations. Therefore, if a rest is used in testing ammunition, the rest should touch the forearm of the rifle and if it is a narrow rest the rifle should always be rested at exactly the same point. There are some prone and bench rests, and very good ones, in which the barrel of the rifle is secured in a clamp; excellent shooting can be done with some of these. While the clamp on the barrel may affect the normal vibration of the barrel, the clamp is affixed at one point and the vibration, although abnormal is consistently uniform.

Powder Gas Disturbances. But to get back to the movement of the bullet. After all parts of the bullet have attained an equal velocity, its movement along the bore of the vibrating barrel depends upon the kind and quantity of powder that is burned behind it. With normal charges of rifle powders, there is some acceleration of the bullet throughout the length of the barrel. This may be seen by cutting off segments of a rifle barrel and noting the drop in velocity of the bullet after each segment is cut off. But if a rifle is fired with a light charge of pistol powder, the powder will be consumed quickly and the bullet given more or less of a bump or shove; as the bullet moves forward and the space behind it increases, the relatively small volume of gas available is unable to continue its accelerating effect on the bullet, the pressure drops rapidly, and the bullet may be retarded or slowed up by friction with the barrel before it leaves the muzzle. High pressures do not mean high muzzle velocities, as with a quick burning powder a gun can be burst before the bullet is out of the barrel, the gas pressure drops to nothing and the velocity of the bullet will be only that imparted to it before the burst occurred, less the retarding effect due to friction before it gets out of the muzzle of the gun.

As the bullet emerges from the muzzle of a barrel there is a tremendous gas disturbance behind it and the gasses, traveling at higher velocity than the bullet, envelop it. If the bases of all the bullets fired are perfectly flat, uniform and free from defects, the action of this expanding gas against the base of the bullet, when the latter is out of the gun, will be uniform from one shot to another. But if the bullet bases are appreciably defective, especially at the edges, the flight of such defective bullets will be affected by the gas.

For example, if a bullet has a nick or a serious casting defect in one side of its base, gas will escape through this as the bullet emerges from the muzzle of the gun, causing more or less tipping or “yaw” of the bullet. While such a bullet may by chance shoot into the same group with the rest, there is a much greater chance that it will not. In pistols and revolvers, where the pressures are low and the range at which such ammunition is fired is short, bullets with minor defects in their bases may appear to shoot fairly well for ordinary use, but not so with rifle bullets. The relatively high gas pressure behind rifle bullets, plus the longer ranges at which such bullets are usually fired, will cause a considerable dispersion if bullets with defective bases are used.

Boat-tail bullets do not behave the same as flat base bullets. A flat base bullet expands under the influence of the powder gasses, but the tendency of a boat-tail bullet is to collapse under the same circumstances. The tapered base of these bullets causes the gasses to act as a wedge and try to force their way in between the bullet and the barrel. For this reason, boat-tail bullets are made with very hard cores and the true base of a boat-tail bullet may be considered as the line of junction between the boat-tail taper and the cylindrical portion of the bullet. Special care must be taken in making such bullets that the boat-tail be concentric with the point of the bullet and that this junction point be in a plane at right angles to the axis of the bullet.

The term “interior ballistics” applies to a sequence of events which terminate when the projectile has left the muzzle of the gun and the report has had time to reach the ear of and register itself on the sensibilities of the firer. The time required for the report to reach the ear is very short and is normally about equal to that required for the bullet to get beyond the effect of the expanding gasses.

Exterior Ballistics.

A bullet suddenly projected in the atmosphere at a high velocity and with a severe gas disturbance behind it is subjected to rough treatment. In the early stages of its flight it may, and usually does, wobble considerably, at the same time deviating more or less from a plane through the axis of the bore. This instability of the bullet is sometimes referred to as “initial yaw.” It is not the same in all bullets, as the shape of the bullet as well as the velocity at which it is travelling has a considerable effect on it. Any eccentric flight of the bullet may be further aggravated by a failure of the center of mass, or center of gravity, to coincide with the center of form.

When the bullet is passing through the rifling, which imparts rotation to it, it is forced to rotate around its center of form, being supported on all sides by the barrel, but when it emerges into the atmosphere, it will revolve around its center of mass. The effort to get these two centers to coincide is one of the major problems of bullet manufacture. If a bullet jacket is thicker on one side than the other, or if the core is not of even density, the bullet will be eccentric in its flight throughout the length of its trajectory. Likewise, a cast bullet can easily be slightly heavier on one side than on the other if the alloy from which it is cast is not kept properly fluxed and stirred. As has been previously mentioned under the subject of bullets, cast bullets frequently come from the mould slightly out of round; these little irregularities are usually trued up by sizing the bullets, but even if they are not and such bullets are fired as cast, they will be sized up and trued to a greater or less extent when they are forced through the bore of the rifle. On the other hand, a cast bullet or even a flat base jacketed bullet is up against a tough proposition when fired in a rifle having a loose chamber, particularly one that is loose at the neck, for as has already been pointed out, there is a brief instant during which the neck of the cartridge is expanded, letting go of the bullet, but in which the bullet has not begun to move forward, after which the base of the bullet begins to move and finally the point, until the bullet slaps up into the throat of the rifle. During this brief instant when the bullet is beginning its forward movement, it is a matter of chance as to how it moves up into the throat of the barrel and its angular entrance, coupled with the expansion which takes place, can cause the most perfect bullet to become slightly eccentric.

The disturbance of the bullet during its initial movement along its trajectory that is caused by its high velocity and the effect of the gas on it is temporary, but any eccentricity of rotation caused by failure of the center of gravity and the center of form to coincide will be permanent throughout the flight of the bullet.

Bullets driven at high velocity will usually make slightly oval holes in cardboard or paper screens placed at short distances from the muzzle of the gun which shows up graphically the effect of initial yaw, but this wobbling of the bullet is also influenced by the shape and sectional density of the bullet and the rate at which the bullet is rotating.

Speed of Rotation. The speed of rotation depends upon the pitch of the rifling and the muzzle velocity of the bullet. For example; if the rifling in a barrel has a pitch of one turn in ten inches and a bullet it fired from it with a muzzle velocity of 2,000 feet per second or 24,000 inches per second, the bullet will, in one second, make as many complete rotations as 10 inches will go into 24,000 inches, or 2,400 rotations per second. However, if the same bullet is fired from the same gun at a velocity of 3,000 f.s. its rate of rotation will be increased to 3,600 revolutions per second. Long bullets must be rotated faster than short bullets to keep them stable in flight or to give them what is known as gyroscopic stability, and a long bullet of small caliber will never become stable in flight if it is driven at too low a velocity.

Trajectory. A projectile emerging from the muzzle of the gun has a tough job ahead of it, forcing its way through the atmosphere. Living in it as we do, we are apt to think that the atmosphere is just about nothing at all, but in reality it is a dense, movable combination of gasses which have a serious retarding effect upon the flight of a bullet or any other object passing through it. The

elastic quality of the atmosphere is responsible for a considerable part of the recoil of a firearm, the action of the gas emerging at high pressure from the muzzle of the gun compresses the atmosphere while the reaction is to force the gun to the rear and the effect on the bullet is to continually slow it up in its flight. As the bullet is unsupported and is acted upon by the force of gravity which is constant, its rate of fall towards the earth is approximately equal to the normal acceleration of gravity while its forward movement is continually decreased by the atmosphere. The trajectory is therefore, always a modified parabola.

The rotation of the bullet is not retarded to the same extent as its forward movement. The point of the bullet thrusts the atmosphere aside much as the prow of a boat thrusts water aside when passing through it, reducing the frictional effect of the atmosphere on the body of the bullet which after all does not involve any compression of the atmospheric medium. Bullets that have been fired at extreme ranges have been found to be rotating after they had lost their forward motion and the same is true of bullets that have been fired vertically, but the atmosphere does cause some retarding effect on the rotation.

Drift. This rotational friction causes the bullet to "drift" slightly in the direction of its rotation or in the direction of the pitch of rifling. Because of the greater frictional area, a large caliber bullet will have a greater amount of drift than a small caliber, all other things being equal. A bullet driven at high velocity from a rifle having a right hand twist may and frequently does move to the left of a vertical plane through the axis of the bore, immediately after leaving the muzzle, but this is due to yaw and not to atmospheric friction. Once the yaw is overcome, the bullet will commence its drift in the direction of rotation.

The trajectory of a bullet with relation to the bullet's performance can be divided into three parts: the part where initial yaw occurs, the part where the bullet flies truly and the part where yaw sets in again. The part in which the initial yaw is pronounced, which varies with the design of the bullet and the velocity at which it is driven, but which in high velocity rifles usually extends several hundred yards from the muzzle of the gun. As the remaining velocity of the bullet decreases, without appreciable decrease in the rotation, the bullet settles down to a steady flight and is said to "go to sleep" and this even flight continues until the loss in velocity and atmospheric friction is so great that the bullet begins to lose its gyroscopic stability. When this point is reached the bullet begins to wobble, which increases its resistance to the atmosphere and it loses velocity rapidly. As its rate of forward travel decreases, the effect of the action of gravity becomes more pronounced and the bullet drops more rapidly towards the earth; if the angle of fire be high enough, the bullet will finally lose all forward velocity and drop straight down.

The calculation of trajectories and in fact, almost all exterior ballistic problems are dependent upon an accurate knowledge of the muzzle velocity of the bullet and a factor termed the "ballistic coefficient," which involves the sectional density of the bullet; that is, the bullet weight divided by the square of its diameter in inches plus a form factor having to do with the shape of the bullet. This applies to flat base bullets. It is a difficult matter to accurately determine the ballistic coefficient of any bullet over its entire trajectory and this coefficient, when determined, can only be applied while the bullet is stable in flight, because the minute a bullet commences to wobble, or is unstable, or eccentric in flight, the air resistance is increased and the normal ballistic coefficient becomes useless.

The most important part of the trajectory and what might be termed the most useful part is that in which the bullet is asleep and flying truly.

CHAPTER TWELVE

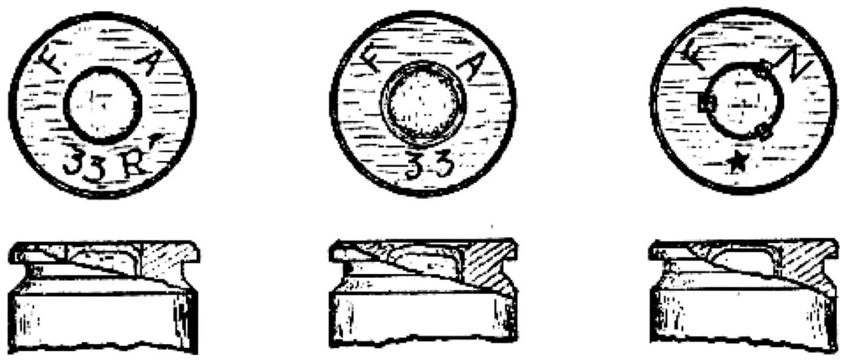
HANDLOADING OPERATIONS.

Except for the quantity of powder used in loading ammunition, which affects the muzzle velocity, the entire problem of handloading is one intimately related to internal ballistics. The first operation presenting itself is that of de-capping, provided one is about to reload fired cases. The expelling of fired primers is of little importance as far as methods are concerned and any old way of getting the primer out is perfectly satisfactory, provided the flash hole or vent in the cartridge case is not enlarged by the de-capping pin or punch that is used. In extracting Berdan primers, care must be taken not to damage the anvil which is a part of the cartridge case, but we can practically skip that because Berdan primers are not used in American; ammunition nor are cartridge cases of the Berdan type reloaded to any great extent.

De-Capping.

All reloading tools provide a means for expelling or pushing out fired primers in the form of a rod or punch that will pass freely through the mouth of the cartridge case. The end of the punch carries a small pin which in turn passes through the flash hole or vent in the case to force the fired primer out. These de-capping punches are actuated by some mechanical means and sometimes operate under a very powerful leverage. This isn't a bad idea, because in military cartridges these primers are almost always crimped in by having the brass in the head of the cartridge case compressed and upset around in the immediate vicinity of the primer pocket, making the month of the pocket smaller than the base. This makes primers especially difficult to push out. Sporting ammunition in other than military calibers is sometimes encountered with the primer crimped in also, so a little extra power or leverage in the reloading tool is not out of place at all on this operation.

The need for removing the crimp from the primer pockets of cartridge cases only exists where the primers have been crimped in and the crimp must be removed before new primers can be seated. We have already gone through the mechanics of reloading and what is written here is intended to apply to the operation of reloading tools with particular reference to the effect that their improper operation can have on the ballistics of the ammunition. Therefore, those little details that have no direct reference to the operation of reloading tools or machines will not be repeated in any detail.



Variations in Primer Crimping.
A—No crimp, as on National Match ammunition. B—Ring crimp, as on Cal. ·30 M1. C—3 point crimp, as on ·50 Cal. ammunition and many foreign cartridges.

Re-Priming.

When it comes to seating new primers, we are up against a real job. The manufacturer of ammunition does this with machines that automatically feed the cartridge cases and the primers in, and position the two in such a way that the seating punch will force the primer squarely into the primer pocket to the proper depth; the travel of the primer punch being adjusted to push the primer in just so far and no more. Naturally this is far enough to press the edges of the primer anvil against the bottom of the primer pocket, but not enough to cause any disturbance or breakage of the primer pellet. This can be done in the factory very nicely because of the rather expensive and ingenious machines used for the purpose, and the fact that all the cartridge cases have primer pockets of a uniform depth and all the primers are uniform within certain small manufacturing tolerances.

The reloader is not in such a favorable position. As often as not he is using cartridge cases from different lots and which are frequently of different makes, with primer pockets that are not all the same depth. As likely as not he is using primers of a different make than the cartridge cases and I am sorry to say frequently pushing them down on top of a lot of dirt and corruption at the bottom of the primer pocket that decreases the depth of the latter. In addition, the reloader is using a loading tool that cannot possibly seat a primer properly if the operator does not use care and judgment in performing the operation.

Priming Punches. It is certainly desirable, but not absolutely necessary, that the shape of the business end of a priming punch conform very closely to the shape of the primer being seated. This is especially true of the new non-corrosive primers, the priming pellets in most of which are quite easily cracked or broken; the softer and thinner the priming cup is, the more desirable it becomes to have a priming punch that fits the primer. With a hard stiff primer almost any priming punch, whether flat or concaved will push the primer in satisfactorily because the pressure required to seat the primer is less than that required to deform the cup. With primers having soft thin cups, of which there are many on the market, all of which are crowned or rounded on top, pressure applied with a flat punch will flatten the center of the primer and may (but will not necessarily) crack the pellet inside. On the other hand, if a punch is used with a deeper concavity than the contour of the primer cup, the pressure will be applied at or near the edge of the cup and it may push the edges down at a greater rate than the remainder of the primer, leaving the crown projecting slightly above the head of the cartridge case when the primer is seated to the bottom of its pocket.

There are two methods of governing the seating of primers. One is by the sense of touch, wherein it is possible to feel the primers seat against the bottom of the pocket. This method is practicable with light hand tools, and with miscellaneous cartridge cases it is one of the best, if not the best, method of doing the work because the operator knows by the sense of touch when each primer is properly seated, regardless of any little differences in the force required to accomplish this from one cartridge case to another. Any slight marking of the primer cup by the punch is not likely to do any harm, but if there is any considerable marking of the cup because of an improperly shaped primer punch, the remedy is to get a different shape of punch if of the interchangeable type and if not to use a different brand of primer which is harder and stiffer and will resist this deformation.

The second method of seating primers is similar to that used by ammunition manufacturers; namely, a priming punch which is adjustable and whose travel can be definitely limited. A reloading tool equipped with such a punch will only do its best work when the punch is properly adjusted and when the cartridge cases all have primer pockets of uniform depth and are supported in such a way that the bottoms of the primer pockets will always be positioned at a uniform distance from the primer punch. If miscellaneous cartridge cases are used or the travel of the primer punch is not properly limited, such a tool would defeat its own purpose for while it might exert the proper pressure and seat some primers very nicely, others could be compressed too much or else not solidly seated to the bottoms of the primer pockets.

The importance of seating primers properly has been gone into thoroughly in the chapter on primers, but as seating primers is one of the most vital, if not the most vital operation in loading or reloading ammunition, some repetition is permissible. As far as the ballistics of the ammunition are concerned, the reloader can only use primers as he gets them and can do nothing about any faults in ignition that may be due to the primer itself. While as igniters some of our present primers leave a lot to be desired, they can in general be classified as good, if they are properly seated, but there are some of them that will not be good if they are not seated with care.

The anvils must be in contact with, and consequently firmly supported by the bottom of the primer pocket. Failure to seat them to the proper depth, or to seat them with so much pressure that the primer pellet is broken inside of them, will adversely affect the accuracy of the ammunition, and don't get the idea that just because a primer punch fits the crown of a primer that the primer can be rammed in without consideration of the force applied to it. If the anvil is not properly supported or the priming pellet is damaged, the

flash from the primer will be different from those that are properly seated. The flash will usually be deficient, but in some primers may actually be excessive. This will cause a difference in the initial ignition of the powder charge and the rate of burning, which in turn will affect the barrel vibration and barrel time of the bullet; that is, the time it takes the bullet to get out of the muzzle of the gun and will cause the bullet to leave at a slightly different point in the cycle of vibration of the muzzle, which may either throw the shot up or down. Wild shots in a group are usually attributed to defective bullets or variations in powder charges, but the reader would be surprised to see some of the things that an improperly seated primer can do.

Many reloading tools combine the operations of expelling fired primers and seating new ones. This is unsound practice but is no reason for condemning a reloading tool providing its design permits the two operations to be separated. The only trouble is that most of these tools have a tremendous leverage available for seating the primer. Furthermore, these tools are for the most part of heavy construction, making it very difficult for the operator to "feel" the primer when it arrives in contact with the bottom of the primer pocket and it is necessary to use such tools with great care in the priming operation if material fluctuations in the muzzle velocity are to be avoided.

Resizing Cases.

Some bench reloading tools or machines are provided with means for resizing cartridge cases full length. This is a great convenience where the cartridge cases must be resized and is a curse where they should not be, because the poor novice whose knowledge of reloading is quite probably limited to the directions he gets with his reloading tool, religiously pumps his cartridge cases in and out of the resizing die because the directions for operating the tool tell him to do it. Sometimes the resizing of the cartridge case is coupled up with the de-capping operation. This is fine for reloading military ammunition where the reloaded ammunition must be interchangeable in a number of different guns and where the cartridge cases must be resized whether they ought to be or not, but for the individual reloading for one gun, the idea is not so hot. The danger of head separations from this cause has been gone into in Chapter One under the subject of resizing cartridge cases, but in addition, resizing the cases destroys the perfect fit of the case in the chamber that was attained by firing it. But a reloading tool is no more to be condemned because it combines these two operations than because it combines the operations of expelling fired primers and seating new ones, as it is usually possible to adjust the de-capping punch downward so that the primer is expelled before the cartridge case is forced completely into the resizing die, permitting the neck of the case to be resized and possibly causing some slight reduction of the forward part of the case, which does no harm.

Whatever the procedure is, all the cartridge cases should be treated alike. When an un-resized cartridge case is put into a chamber, the case is to all intents and purposes in intimate contact with the chamber walls. On the other hand, a cartridge made up with a resized case will fit in more or less loosely in the chamber and when fired the gasses must perform the work of expanding the case to the limits of the chamber and forcing out the air between the case and the chamber, this air having a sort of cushioning affect. This is not of serious consequence, but any reloader who wishes to get the best out of his reloaded ammunition must bear in mind that uniformity is the very essence of accuracy and everything possible should be done to keep barrel time and barrel vibration uniform.

Muzzle or Neck Resizing. This operation is not of much importance except as an aid to holding the bullet. It is divided in two parts, the reduction in diameter of the outside of the case neck and the subsequent expansion of the inside to the proper diameter or dimensions for the bullet. These two operations are frequently combined in reloading tools by the simple expedient of having the expanding plug and resizing die assembled in such a way that when the reduced neck is withdrawn from its die it is pulled over the expanding plug. This is O. K. but a better job can be done by divorcing the two operations and expanding the mouth of the case to a diameter that will permit the bullet to enter freely for a short distance. This is especially desirable when seating cast bullets, as it absolutely eliminates the possibility of shaving metal off the side of the bullet and furthermore, insures that the bullet will start straight into the neck of the case. This is explained elsewhere. This method of seating bullets cannot be carried out if the operations of reducing the neck and expanding it are combined. If an expanding plug is used that is large enough to open the mouth of the case sufficiently so that a bullet may be entered easily, the expansion will exist throughout the length of the neck which has been pulled over the expanding plug and the neck of the case will not hold the bullet at all.

Some reloading tools that do not support the body of the case while the neck is being resized have a tendency to size the necks slightly off center. This may be due to variations in thickness or hardness around the case neck aggravated by lack of support in the tool. It is not a desirable condition but it doesn't have any appreciable effect on accuracy unless under some exceptional circumstances. This may sound "fishy" to the theorist who argues that if the bullet is not concentric with the body of the cartridge case it will not be in line with the axis of the bore. As a matter of fact, if the bullet is concentric with the body of the cartridge case it will not be in line with the axis of the bore unless the cartridge case is a perfect fit in the chamber. If the fired cartridge case will go in the chamber before the neck is reduced it will go in afterwards, regardless of how the neck is reduced. As has been pointed out above, when a cartridge is fired in a normal chamber having a tolerance of several thousandths of an inch, the gasses expand the case to the limits of the chamber at an early stage in their development and before the bullet commences to move forward. This leaves the bullet temporarily suspended and without support and it is purely a matter of chance as to just how it "whops" up against the throat of the rifling when it moves forward regardless of whether it is concentric with the body of the case or not.

Regardless of the exact methods used to reduce and expand the necks of cartridge cases, all reloading tools provide some means for doing this and doing it satisfactorily. The exact method used is largely a matter of preference. Resizing the necks of cartridge cases is advisable in loading rifle cartridges and is an absolute necessity when loading them with jacketed bullets. Many jacketed bullets have no cannelures in which the cartridge case may be crimped and if they do have they are usually so shallow that the expanded mouth of a fired cartridge case cannot be crimped on to them securely enough to hold them in place with certainty. Lead bullets can usually be held in place by the crimp alone and sometimes with beneficial results as we will see later, but generally speaking the operations of resizing and expanding necks of cartridge cases should be performed on rifle cartridges.

Chamfering Case Mouth. When cartridge cases are trimmed to length during their manufacture they are usually cut off square on the ends. As the cutting is done from the outside towards the center, the inside edge of the mouth of the case is left quite sharp. As the cutting tool becomes dull a burr is set up on the inside of the case mouths. If these cases are to be loaded with lead alloy bullets, this burr is removed by a chamfering or beveling cut to permit the entrance of the bullet without scraping or shaving metal from the side of it. This operation is considered unnecessary on cartridge cases that are to be loaded with jacketed bullets because the danger of

deformation of the bullet is not present, inasmuch as the bullet jacket is practically as hard and indeed sometimes harder than the cartridge case. In reloading ammunition, cartridge cases that were originally loaded with jacketed bullets are frequently reloaded with cast bullets and it is advisable for the reloader to examine his fired cases and those that are not properly beveled on the inside edge should be so beveled or chamfered that there will be no danger of the sharp inside edge of the mouth deforming the bullets when they are seated. A sharp knife is about as good as anything for this purpose or a reamer may be used.

This little operation, which is very simply performed with any sharp instrument, doesn't pertain directly to the use of reloading tools proper, which is the subject of this chapter. Nevertheless, it has a great deal to do with the satisfactory seating of bullets and consequently with the results obtained with any reloading tool.

Crimp Removal. Another little detail that does have a great deal to do with the reloading tool is the matter of the removal of the remaining crimp from fired cartridge cases. Not all, but the majority of commercial or sporting cartridges are crimped; that is, the mouth of the cartridge cases are turned into a groove in the bullet to aid in holding it in place. Crimping cold works the mouth of the case, hardening or stiffening the brass slightly. As has been pointed out, when a rifle is fired the cartridge case is expanded to the limits of the chamber. Whether the pressure and the time for which it is exerted on the case is sufficient to flatten out the crimp entirely, I do not know, but if the gasses do this, it is certain that the hardness and resilience of the crimp causes it to spring back part way after the pressure has dropped, and fired cartridge cases that have been crimped are usually found so small at the mouths that new bullets will not enter them. This crimp must be removed and furthermore, it should be removed before the cases are chamfered. Reaming this crimp out is a makeshift, and repeated crimping and reaming to remove the remaining crimp after firing will eventually shorten the cases. This in itself is not harmful, in fact it isn't a bad idea on rifle cartridges because such cases, when fired with heavy loads, have a tendency to lengthen. However, the evil lies in the fact that the cases become of unequal length and this in turn promotes unevenness in the crimping when they are reloaded.

The proper way to remove remaining crimp is by bending it out by forcing the case against a cone shaped plug or shoulder. Some reloading tools lack any means for performing this operation and their design is such that they cannot perform the job well at all, but it can be done quite satisfactorily and rapidly by standing the cases on their bases on a bench or table, inserting a tapered plug successively in the mouths of each cartridge case and striking the upper end of the plug a light, sharp tap with a stick of wood. A few trials will serve to show how hard to hit the plug without flaring the mouths of the cases excessively, although a slight flare is not objectionable. Any object of convenient size and shape can be used for this purpose as the sole function is to get the crimp out of the way so that a new bullet can be seated and there is no need for any complicated apparatus to do it. This little operation also aids in removing dents and at least partially true’s up the mouths of cases that have been bent. The common cylindrical form of expander is worthless for removing the crimp; with it the crimp is pushed back while the plug is entering and being withdrawn from the case, but as soon as the plug is out, the crimp springs back nearly to its former position. If the expanding plug has a shoulder on it against which the mouth of the case can be forced in the expanding operation, it makes a very convenient way of doing the job, but unfortunately all reloading tools cannot use a plug of this type.

Powder Charging.

The necessity for uniform powder charges and the methods of weighing and measuring them are taken care of elsewhere in detail, and no further space need be given to it here except to say that for best results the powder measure should be entirely divorced from reloading tools or machines. Factory ammunition is charged with powder by mechanical means, but we have already seen that unrelenting vigilance and inspection are necessary in order to do this successfully. The affect of variations in powder charges is to cause variations in muzzle velocity, even when the ignition is uniform.

Seating Bullets.

All reloading tools have a die, punch, plunger or screw which serves to seat the bullets in cartridge cases, with the exception of some special loading dies on hand tools made for special cartridges. These bullet seating punches are adjustable so that the depth of seating of the bullet can be accurately controlled. These seating punches may be roughly classified into two general types: those that seat bullets from their points and those that seat from the ogive, or the curved or tapered portion of the bullet.

The ones that seat from the point will give greater uniformity of depth of seating, as they will seat the bullet exactly the same distance from one cartridge to another. Those that seat from the ogive will not do this because there is apt to be some slight differences in the curvature of the ogives of bullets, This is especially true of jacketed bullets and because of variations in the bullets there will be some variation in the over-all lengths of the cartridges in which bullets are seated by this method, which means that there is some variation in the depth of seating of the bullets. As in all other operations in making ammunition, a certain tolerance is permissible in the bullet seating depth and both types of seating punches can be considered as satisfactory, even though point seating is slightly preferable.

It is advisable but not always necessary, to use a bullet seating punch or screw that conforms closely to the shape of the bullet being seated. This is especially true when seating cast bullets. All of the reloading tool manufacturers can furnish bullet seating attachments that are satisfactory for use with any one of the many cast bullets that are available, regardless of who they are made by. If an improper bullet seating punch is used with a cast bullet it will cause some slight marking or deformation of the bullet nose or point when the bullet is seated, but this is seldom sufficient to be of practical importance as far as the flight of the bullet is concerned. However, in ordering these items or in ordering your reloading tool the purchaser should specify what bullet he intends to use in it and if it is a cast bullet he should give the name of the manufacturer of the bullet mould and the manufacturers complete number for the bullet. If there are any letters connected with the number, be sure to give those also.

Seating Depth of the Bullet.

Most modern tables of charges give, in addition to the weight of charge and other pertinent information, the depth of seating of the bullet that was used to obtain the ballistics shown in the table. This depth of seating may be expressed in terms of the actual distance

that the bullet is seated in the neck of the case, or in the over-all length of the cartridge. The writer prefers the latter method, because cartridge cases and consequently cartridge case necks are not all of a uniform length. If the bullets are all seated to a uniform distance by measurement on the bullet itself, the bullets will be at slightly varying distances from the bases of the cartridge cases. On the other hand, if the over-all length of the cartridge is taken as the unit of measurement, the bases of the bullets will be at a uniform depth regardless of any little differences in the length of the case necks. The variations in cartridge case lengths are normally small but they lengthen out to a greater or lesser extent from repeated reloading and must finally be trimmed or reamed back or the mouths of the cases will butt into the forward shoulder of the chamber. Under ordinary conditions the difference in the relation of the base of the bullet to the powder charge, or the capacity of the cartridge, as between measuring the actual seating depths of the bullets and the over-all depths of the cartridges, will be slight indeed, but when we work in the other direction we find another factor.

If the cartridge cases are of different lengths and the bullets are seated to a uniform depth according to the measurement on the bullet itself, the bullets will be at varying distances from the throat of the rifling. On the other hand, if the measurement is taken by over-all length on the cartridge, the bullets will be a uniform distance from the throat. If one bullet moves from ·004″ or ·005″ or possibly more than another before coming in contact with the rifling, it will strike a harder blow than it will in moving a shorter distance and will certainly have some varying affect on the barrel vibration. Therefore, by measuring the over-all-length of the cartridge we have a slight advantage in both directions.

The depth of seating of bullets as given in tables of charges need not be adhered to except when loading the heaviest recommended charges. Under such circumstances the seating depth given in any table should not be exceeded. It may be decreased with beneficial results for reasons that will be discussed later. With reduced powder charges an increased seating depth is permissible, but seldom desirable.

If the mouths of the cases have been opened up sufficiently so that the base of the bullet can be entered into the neck for say 1/10″ or more with the fingers and the case mouths have been chamfered or beveled, cast bullets can be seated perfectly all the time. If on the other hand, the expander used leaves the neck of the case a size that requires the bullet to be forced in, the chances are not so good, for in this condition the base of the bullet must be placed against the beveled mouth of the case and twisted a little to make it stick in place; perched in this precarious manner there is no telling what may happen to it when it is put into the loading chamber of the tool. As often as not the bullet is dislodged by contact with the inside of the chamber and is dependent upon Lady Luck to steer it into the mouth of the case again. Flaring the mouths of cartridge cases helps to avoid trouble when the case necks are undersize.

Cannelures.

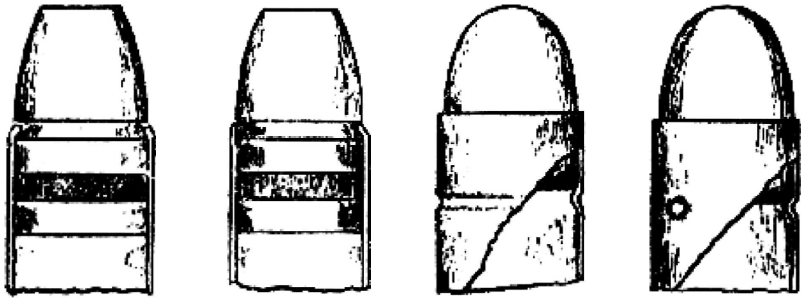
Some cartridge case necks have cannelures in them; that is, a groove rolled in around the neck of the case. Factory ammunition is loaded with the cases in a vertical position and these cannelures are put in to limit the depth of seating of the bullet. Occasionally, cases that happen to be thin at the neck will be so large that the bullets would drop right down on to the powder if there were no cannelures there to stop them and such cartridges would have to be scrapped. In reloading cannelured cases it is desirable to use bullets that will give the cartridge the proper overall length, without forcing the base of the bullet beyond the cannelure. If bullets are seated so that their bases go in beyond the cannelure the cases will be bulged at the cannelures and the ammunition will probably not chamber. This trouble can be remedied by placing the necks of the loaded cartridges one at a time on a flat strip or plate of steel and rolling the cartridge with another flat piece, at the same time applying considerable pressure. Between the rolling and the action of firing, the cannelures will usually be flattened out sufficiently with one or two re-loadings so that they will cause no further trouble.

Crimping.

When ammunition for any arm is reloaded without resizing the case necks sufficiently so that the tension of the case neck alone will hold the bullet in place securely, the cartridge cases must be crimped or turned over onto the bullet to hold the latter in place. Cartridges for use in rifles having tubular magazines must be crimped and crimped quite heavily and it is desirable to have the bullets in such cartridges seated friction tight as well. When cartridges are inserted into a tubular magazine they lie end to end and compress the magazine spring, which exerts pressure on the column of cartridges to force the rearmost cartridge back into the carrier when the latter is in its lower position. When the rifle is fired the column of cartridges does not recoil at the same velocity as the rifle as they are not held rigidly in place, being supported at the front end by a compressible spring. As a result, a considerable part of the energy of recoil is stored up in the magazine spring which subsequently exerts this stored up force on the column of cartridges, driving them to the rear. This force tends to shove the bullets back deeper into the cartridge cases and the crimp helps to resist this. In un-cannelured cases, the crimp may be insufficient to keep the bullets from being forced back into the case. This is especially true when the magazine is nearly empty as the reduced compression of the magazine spring permits a greater movement of the cartridge column and consequently the cartridges attain a higher velocity of movement in the magazine under the impulse of the spring.

An old method of aiding in checking the receding of the bullets into the cases is to indent the neck at several points just in the rear of the location of the bullet bases. Of course, if the cases are cannelured this need not be done, but if the case has no cannelure or if the cannelure is shot out and experience shows that the bullets do recede into the cases, it is about the only remedy that can be applied.

Indenting case necks has an objection when cast bullets are used. A cannelure will support the base of the bullet all the way around, giving a uniform distribution of the stress on a bullet base. Indentations are so localized that when a bullet is forced back against them, nicks or depressions are put in the bullet base at the points of indentation. If the condition is bad enough, it will have a slight detrimental affect on accuracy, but as most tubular magazine rifles do not develop the highest degree of target accuracy anyway, this is probably of little practical importance. In any event, a good heavy crimp will help to prevent the bullets from receding,



A B C D

Bullet crimps and cartridge cannelures.

A—Bullet crimped into mouth of case. B—Imperfect crimp, deeper on right side than on left. C—45 Auto case, with square shoulder at mouth and case cannelured to prevent bullet from seating too deep. D—Same as C except case is indented instead of cannelured.

Revolver and automatic pistol cartridges must be crimped quite heavily, as the resistance offered to the forward movement of the bullet by the crimp is an important factor in promoting proper combustion of the powder charges. The one noteworthy exception to this rule is the ·45 Colt Automatic pistol cartridge. This cartridge should *never* be crimped, as it is positioned in the chamber of the pistol by the square forward edge of the case contacting a corresponding shoulder in the chamber.

Crimping is also advisable in rifle cartridges using light charges of quick burning powders and is sometimes desirable with heavier loads in single shot rifles and repeating rifles having box magazines.

In all reloading tools, crimping is accomplished by forcing a coned or tapered shoulder in the loading chamber against the mouth of the cartridge case, or vice versa. This is usually accomplished at the same time that the bullet is seated to the proper depth. As most reloading tools have that portion of their loading chambers that receive the neck, made large enough to handle cartridge cases that have been expanded by previous firing and have not been resized, these chambers are slightly over-size for cases the necks of which have been resized. This frequently causes a resized case to slide a little bit to one side or the other, causing the crimp to be turned over a little more heavily on one side than the other. This unevenness in crimping, while not desirable, does not have a serious affect on accuracy as is commonly supposed, but the unevenness can be at least overcome to some degree by partly crimping the cartridge, then turning it around 180 degrees before completing the crimping. The condition is found alike in the straightline, as well as the tong types of tools.

Water-proofing Ammunition.

Ordinarily, there is no object in water-proofing hand-loaded ammunition. Such cartridges are usually fired within a relatively short space of time after being loaded and under conditions where water-proofing would be unnecessary. However, if one wishes to water-proof his ammunition, it may be done as follows.

After the cases are primed, put a drop of lacquer on each primer. Ordinary quick drying, clear lacquer may be used. It can be applied with a tooth-pick or any other slender stick which, when dipped into the lacquer, will pick up a drop. The excess lacquer should be wiped off by rubbing the head of the case across a piece of cloth laid flat on a table, after the lacquer has flowed all around the edge of the primer.

This lacquer around the primer should be allowed to dry thoroughly before seating the bullets. This is especially necessary with short cartridges where the bullet occupies a considerable part of the space in the case. If bullets are seated in such cases before the lacquer is dry, the bullet, acting as a piston, will compress the air in the case, forcing it out around the primer and breaking the seal.

If the mouths of the cases are to be water-proofed also, they must be resized so the bullets will be held friction tight. After the cases are charged with powder, a thin coat of lacquer should be applied all around the insides of the necks and allowed to *partially* dry before the bullets are seated. As the bullets are pushed down, their bases will shove the gummy lacquer along, forming a thick seal around the base of the bullets. A bit of actual experience is necessary here in order to do the job right. Do not use so much lacquer that it will flow or run down on the powder and do not seat the bullets too soon after applying the lacquer, as it may still be soft enough to run down after being scraped up and formed into a seal by the bullet bases.

Inspection.

It may appear to some readers that my many comments on inspection are exaggerated, but they are not. Not much mention of its importance has previously been made in books on handloading because, until quite recently, loading tools performed their operation one at a time, or in such a way that the reloader could always see just what was going on, readily observing any defects in the components and loading while doing the work. In other words, the inspection took place without conscious effort or thought on the part of the individual.

In recent years, a demand has arisen for loading tools which will load ammunition rapidly and a number of new tools have made their appearance on the market which combine the necessary operations so as to produce ammunition more *rapidly,* regardless of any other considerations. Now let's take a look at this demand. Does it arise with people well informed on ammunition and handloading? It does not! It comes from the rank and file with a superficial knowledge of handloading or none at all, folks who have a yen to spend less time reloading ammunition and more time shooting it, which is a very good idea indeed if carried out intelligently. Whether some of the newer tools and machines have been turned out by mechanics or firms with the business acumen to take advantage of the sucker demand, or by those with no more knowledge of handloading than the demanders, I don't know and care less. Neither do I mean that every loading tool that comes out is bad just because it is new. As a matter of fact, most of them can be used with safety and

satisfaction if the user will observe the fundamental principles of cartridge loading, the first and most important of which is *inspection.*

In the manufacture of new ammunition with modern precision machinery it might appear that the product would flow through the machines and come out perfect with a little watchfulness and gauging here and there, but it will not. Taking the ·30-06 military cartridge as an example, the number of manufacturing operations varies a little with different manufacturers but there are about 110 of them and they all have to be inspected. Of the total labor cost of manufacturing this cartridge, making the clips, bandoleers, boxes, tin liners, packing the ammunition, sealing the cases and marking them, 15% is for inspection. The cost of inspecting the ammunition is about 55% of the labor cost of making the cartridge case alone. If the reader were to go through an ammunition factory he would probably come out with the impression that about 50% of its employees were inspectors, and these inspectors that one sees devoting all their time to such work does not include the gauging and watchfulness of the machine operators themselves.

In reloading ammunition, safety depends largely upon cartridge cases which have been strained more or less by previous firing and it is necessary to pay attention to inspection *all along the line.* This necessity becomes more important as the power of the reloads increases and any reloading tool should be used in a way that will permit careful and continuous inspection, regardless of how slow the operation of the tool becomes in so doing. Remember, it is brains rather than hands that make safe and satisfactory ammunition. If you do not use the brains, you may suddenly find yourself with half a handgun missing from above and a couple of fingers off from below, or you *may* come out with an eye or two gone and a puss full of brass and steel fragments. Intelligent handloading just can't leave inspection out.

CHAPTER THIRTEEN

REVOLVER AMMUNITION.

Handloading ammunition for revolvers is the same as loading for any other kind of a cartridge from a mechanical standpoint but like loading any other cartridge, doing the work intelligently depends largely upon a consideration of the type of arm the ammunition is to be fired in. Everyone knows what a revolver is; a firearm having a frame which carries the lock mechanism, into which a barrel is fitted, with a cylinder in which the chambers are reamed and which rotates so as to align the successive chambers with the barrel as the arm is fired. Due to the separation of the chambers from the barrel, there is a considerable amount of gas leakage between the barrel and cylinder each time the arm is fired.

This type of firearm is of three general designs. The first type has a solid frame and the cylinder is attached to it by the pin or rod on which it rotates and can only be removed by first removing this rod. The Colt single action Army model and the miscellaneous lot of low priced revolvers of different makes are examples of this class.

The second type is the so-called “top break” in which the frame is divided into two parts, the top strap and front of the frame carrying the cylinder pin, cylinder and barrel; the frame being hinged at the front end (usually at the lower part of the frame). The rear part of the top strap carries a latch for locking the gun when closed and the arm is loaded by unlocking the latch and tipping the barrel downward, an action which usually causes the ejection of any cartridges or cases that may be in the chambers and exposes the chambers for loading. Some of the older Smith & Wesson’s, the British Webley and a great variety of cheap and moderate priced revolvers are examples of this type.

The third class, which is confined chiefly to modern Colt and Smith & Wesson revolvers and cheap foreign imitations of them, has a solid frame to which the barrel is permanently attached, while the cylinder and its pins are mounted on a crane which can be swung out to one side when unlocked.

Each of these types has its advantages and disadvantages, which need not be discussed here, but all of them possess peculiarities that are not found in any other type of arm and all of them must have a much greater amount of head space, or clearance between the heads of the cartridge and the standing breech, than would be permissible in a rifle. This is necessary to permit free rotation of the cylinder and smooth functioning of the gun. It is permissible in a revolver and is possible only because of the relatively low pressures that are developed by revolver cartridges; the limit of which is nominally considered as 15,000 pounds per square inch, but which runs to 20,000 pounds in some of the high speed cartridges and to nearly 40,000 pounds in the ·357 S. & W. Magnum. The latter, by the way, had to be specially constructed to handle cartridges developing such high pressures.

When a revolver is discharged, the cartridge fired is driven forward by the blow of the firing pin and subsequently is forced back sharply against the standing breech by the pressure developed within it. The remaining cartridges in the chambers are also thrown back violently by inertia. The more modern revolvers have a separate piece in the form of a bushing or plate forced into, or dovetailed into the rear of the frame, or standing breech, having a hole through which the firing pin or hammer nose passes. This separate, replaceable piece is put in because this hole is subject to wear and if enlarged too much the primer, weakened by the blow of the firing pin, may pierce or blow out, blowing the hammer violently back to its rearmost position, with damage to the mechanism and possibly minor injuries to the shooter's hand.

In the side swing revolvers, this recoil plate takes the form of a small disc forced into a recess in the frame itself. This disc must take the thrust of the set-back of the primer and in the case of small cartridges, such as the ·32 S. & W. and similar sizes and to a slightly lesser extent with the ·32/20, practically the entire thrust of the cartridge head. If cartridges are over-loaded, their continual use is liable to set the recoil plate back, permitting the primers to project above the heads of the cartridge cases, thereby impeding rotation of the cylinder. For this and other reasons, the common belief that the strength of a revolver and its ability to handle heavy loads is dependent entirely upon the strength of the cylinder is erroneous.

The general operating principle of a revolver is as follows: The cylinder carries a ratchet at its rear end in close proximity to the frame and is rotated by means of a pawl or “hand.” The hand in single action guns is attached to the hammer, in double action guns to the trigger. This hand projects through a slot in the rear of the frame, to one side or the other of center and is thrust upward by the action of cocking the gun (or in the case of double action guns by pulling the trigger) and the upward thrust of the hand causes the

cylinder to rotate. The outside of the cylinder has a series of equally spaced depressions, or bolt stops, milled in it, equal in number to the number of the chambers. Projecting through the bottom of the frame is a small movable piece or lug called the "bolt" which, at the proper time, comes up and enters one of these depressions in the cylinder, acting as a stop or lock to position a chamber in line with the barrel and also with the hole in the recoil plate so that the primer will be struck by the hammer nose and the bullet will enter the barrel. The bolt remains in this position from the time the gun is fully cocked until it is fired, and is not depressed or unlocked from the cylinder until the arm is cocked for firing again.

The common belief is that each time a revolver is cocked the uppermost chamber is in perfect alignment with the axis of the bore of the barrel but, unfortunately, this is not exactly true. In Colt revolvers the cylinders revolve to the right. The hand is located as far as possible to the left of the center of the frame and the bolt as far as is convenient to the right of the bottom of the frame. These guns are so adjusted that when the trigger is at its rearmost position, or at the position at which it is when the sear is released and the arm is fired, the hand is exerting pressure on the cylinder, rotating it against the resistance of the bolt. In other words, with the trigger all the way back, the cylinder is locked.

The method of checking the alignment of the chambers with the barrel, when the cylinder is in position for firing, is to pass a plug gauge that fits the bore closely through the barrel and into each chamber. If the plug passes freely into the chambers, the alignment is considered correct. It should be borne in mind, however, that this plug is of bore and not groove diameter. Therefore, a chamber might be out of alignment by as much as the depth of one groove and the plug would still enter freely. Furthermore, the throats in the cylinders, or that portion just ahead of each chamber which acts as a guide to the bullet before it enters the barrel, are invariably of larger diameter than the groove diameter of the barrel. It will, therefore, be seen that it is possible for a chamber to be several thousandths of an inch out of alignment and still pass the factory test.

In Smith & Wesson revolvers the mechanism is so adjusted that when the cylinder is in the firing position there is a slight amount of play in it. This play is apparently purposely left to give the cylinder itself a chance to compensate for any small variations in alignment when the bullet is passing from the cylinder into the barrel. Whether there is time for any such compensation is questionable, but certainly the principle is not harmful even if the practical effect is not apparent.

I realize that many revolver shooters will be horrified to learn that their cylinders do not necessarily line up precisely with the barrels of their revolver, but the little variations which do exist should not be considered so much in the light of defects as merely limitations that are necessary in the particular type of arm.

Anyone can very easily examine his own gun for alignment if he wishes to verify these statements. All that is necessary is to cock the gun, holding its trigger and the hammer back. At the same time, point the gun towards a strong light or insert a small flash light in the muzzle, then look through the hole in the recoil plate from the rear. By looking past the hammer on either side, it is possible to see both sides of the bore through the chamber. If there is any play in the cylinder it can be worked back and forth so that its relation to the barrel may be seen. If you do this little stunt, don't throw a "cat fit" over what you see, or complain to the manufacturer that your gun is no good. The revolver is an intricate piece of mechanism and it is remarkable that the manufacturers are able to get the cylinder alignment as good as they do, without making the cost of the guns prohibitive.

The revolver is essentially a short range weapon. Fired with one hand, unsupported and with such a short sight radius, no one expects to get 1″ or 2″ groups at 100 yards, nor could they, except by luck, no matter how accurately a revolver might be made. The longest range at which one is ordinarily used is about 50 yards and all revolver targets have bullseyes and counting rings very much larger than rifle targets used at similar distances. Yet in spite of the limitations in the design of revolvers, and the minor tolerances in their working parts, they will shoot with excellent accuracy provided the capabilities of the shooter are equal to those of the gun.

However, to further assuage the feelings of those individuals who may have believed that the chamber and barrel alignment of revolvers is the very essence of perfection it may be stated here, leaving the details until further along, that even though cylinder alignment IS perfect, it is a matter of chance whether or not a revolver bullet passes from the cylinder into the barrel with its axis in perfect alignment and coincident with the axis of the bore.

Bullet Jump.

As the chambers of a revolver are entirely separate from the barrel, it is impossible for the bullets to be in close contact with the rifling before they are fired. The bullets must jump forward at a considerable velocity and more or less without support before they strike the rifling. They also must be seated deeply enough in the cases so they will not project beyond the front ends of the chambers, as this would prevent the cylinders from rotating.

The throats of the chambers are always larger in diameter than the groove diameter of the barrel and normally, revolver bullets do not upset or expand much when they are fired. The degree of upsettage, if any, depends upon the hardness of the bullets and the nature of the powder charge used behind them, but as a general rule solid base bullets do not expand sufficiently to fill the throat, consequently the bullet must pass from the chamber into the barrel more or less unsupported. The accuracy of the arm depends largely upon how well the bullet is guided between the time it leaves the case and enters the barrel. If an attempt were made to load bullets that were as large in diameter as the throats of the chambers, the resultant cartridge would in most instances be so large at the neck that the ammunition would not enter the chamber. Furthermore, this diameter might be so much greater than the groove diameter of the barrel that dangerous pressures might develop from attempting to force such an oversize bullet into the barrel.

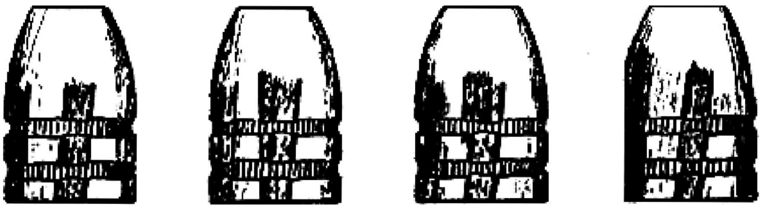
Bullet Slippage.

The considerable jump that a revolver bullet must make before it comes in contact with the rifling permits it to attain a rather high velocity, consequently its contact with the lands and grooves is accompanied by a considerable shock. Due to this velocity that it attains while moving forward through the throat of the chamber and the barrel cone, it has a tendency to drive straight forward into the barrel, ignoring the rifling. Normally, the resistance offered by the inclined driving edges of the lands cause this forward movement to be overcome quickly, and under conditions of proper loading the bullet usually attains its normal rate of rotation before it has entered the rifling for its entire length. These "slippage" marks can be seen on almost any of the bullets illustrated in this chapter of the text.

The amount of slippage depends upon the hardness of the bullet, its velocity, the nature of the rifling and the relation between the bullet and bore diameters.

If a soft, short revolver bullet is fired at too high a velocity these slippage marks will extend all the way back to the base of the bullet. If in addition the barrel is a short one, the bullet may never attain its proper rate of rotation. It is doubtful if this is true in a barrel of normal length, say from 4″ up, for after all a bullet depends for its rotation only upon one edge of each land of the rifling and even though a short bullet does show slippage clear to its base, it may still acquire a normal degree of rotation because of the resistance offered by the driving edge of the lands. In actual practice, however, bullets which show an abnormal degree of slippage do not perform well and it is advisable not to use short bullets for so called high velocity loads. When using such loads the bullet alloy should be stiffened or hardened. This hardening of the bullets when used with the heavier loads has a three-fold beneficial effect. The slippage is reduced. There is less tendency for the bullet base to upset excessively when passing from the cylinder into the barrel. There will be less tendency for the barrel to lead than if a softer bullet were used. All of these things contribute to good accuracy.

As a matter of fact, the normal jump of a rifle bullet may also be sufficient to cause some slippage, but as rifle bullets normally jump a much shorter distance than is the case in revolvers and because of the use of slower burning powders, they probably do not acquire as high a velocity over the short distance of jump as a revolver bullet. Therefore, the effect of slippage in a rifle is negligible, especially with jacketed bullets, and can practically be eliminated by seating the bullets out of the cases far enough so that they will be in contact with the rifling before the cartridge is fired.



A B C D

Results of slippage, tipping and shaving of bullets.

A—Fired bullet showing perfect rifling marks, no indications of tipping, slippage or shaving. B—Bullet showing slippage. Note that left hand edge of rifling mark on bullet is straight, showing that bullet plowed straight forward into rifling for some distance before taking up rotation. C—Bullet showing two sets of rifling marks with different angles, indicating that bullet was badly tipped when it entered bullet seat, but later straightened up. D—Bullet badly shaved on left side as a result of poor alignment of revolver cylinder.

In revolvers, the general rule is to use moderate loads with short or soft bullets and longer and harder bullets for the heavier loads.

Very rarely a revolver barrel will split at the rear end but this can be caused by the excessive upsetting of a soft bullet just as well as it can by a jacketed bullet and is not likely to happen at all with a cast bullet made from a fairly hard alloy.

Bullet Diameter.

In rifles the groove diameter of the barrel may be used as a guide for the proper sizing of cast bullets, but with the revolver, consideration must also be given to the throat; as a consequence, it is common to find that revolver bullets are smaller than the throats of their chambers and sometimes several thousandths of an inch larger than the groove diameter of the barrel. It is disadvantageous to use bullets that are much above the standard size of revolver bullets loaded by the commercial ammunition manufacturers. These bullet diameters have been arrived at as the result of long experience in many different arms and while some departure from these standards is permissible in some individual weapons, it cannot be recommended in general.

Now let us take a look at what happens if an over-size bullet is used. When a cartridge is fired, the cartridge case expands before the bullet has time to overcome its inertia and move forward, because less pressure and time are required to expand the thin case than to move the comparatively heavy bullet. In other words, the case lets go of the bullet first. The crimp, especially if it is a heavy one, may retard the forward movement of the bullet, but probably most of this crimp is forced out by the gas pressure, even though the crimp later springs back part way. As the bullet is at best smaller than the throat or guiding portion of the chamber it is a matter of chance as to the direction and amount of tip that the bullet takes before it enters the barrel. With bullets of standard diameter in modern guns there is not a great deal of tipping, if there was we would not get the accuracy we do; but, even so, the bullets do usually strike on one side of the rifling harder than the other. That this is true can be readily determined by marking the bullets to indicate their positions when fired and examining them after they are recovered. This condition may be aggravated by a slight misalignment of the chamber and barrel, but it occurs with ammunition fired from chambers that are in perfect alignment with the barrel. On the other hand, there are indications that at times a small error in alignment may actually compensate for any slight tipping of the bullet. Now if bullets are sized down to the groove diameter of the barrel, the clearance between the bullet and the guiding walls of the throat of the cylinder, upon which it depends for its alignment, will be increased and the angular entrance of the bullet into the barrel may also be increased.

In determining the proper diameter for revolver bullets, this haphazard movement of the bullet before it comes in contact with the rifling, the relatively large diameter of the throat, and relatively small diameter across the grooves, leaves one between the devil and the deep blue sea, except for the one saving grace that even experienced reloaders sometimes overlook. This saving grace is the standard diameter of revolver bullets—that has been determined upon after years of experience and experimentation. I repeat that this does not mean that the diameters of cast bullets for revolvers should not or cannot be varied from the factory standard to meet little peculiarities in individual guns, but it does mean that unless the reloader has had considerable experience with reloading, he will probably get the best results if he sticks to the standard factory diameters.

The question may arise as to how much difference a few thousandths of an inch one way or the other from the standard bullet diameter will make in the accuracy of the ammunition. There is no fixed rule. The difference will usually only be slight and probably

not enough to be noticeable to the average pistol shooter—but there is a difference. Comments of this kind are apt to create the impression that a bullet of normal diameter will shoot well, while one of slightly smaller diameter will shoot all over the lot. This is not necessarily the case, but it is true that the difference will be more noticeable with short light weight bullets than with the longer bullets of standard weight. The shorter bullets have more opportunity to tip and their angle of tip will be greater than that of a bullet of normal bearing length. One of the advantages of sharp shoulder bullets lies in their longer bearing length and the lesser opportunity there is for them to tip while passing through the throat, but such advantage as this may give them is more than offset by their miserable ballistic shape.

Leading.

There is another factor to be considered; namely, leading. I have mentioned the subject of leading in a number of places in this book and have quickly steered off from it onto something else. The reason is that I know very little about it. I have been fooling around with the subject and experimenting with it for about 14 years and with all types of weapons and I can't give a definite solution to this problem for any particular type of gun. What works in one gun doesn't seem to work in another, but there is one thing that can be stated quite definitely and that is that the relation of bullet diameter to throat diameter in a revolver has some bearing upon leading. If the clearance between the bullet and the throat are sufficient (and they usually are) gas rushes past the bullet, blowing particles of lead from the edges of the base and the bands; if these particles of lead adhere to the barrel, leading will build up. The bullet diameter is not the whole story and the actual clearance between it and the throat involves the bullet hardness and the powder charge used behind it, and the bullet hardness involves the alloy which also has something to do with the question.

If the reader is inclined to doubt that lead is blown off from the bullet before it enters the barrel, he should examine the outside of the cylinder of his revolver the next time he gets through shooting it. Over the top of each chamber at a distance of about 1/4″ back from the front end of the cylinder there will probably be a distinct and heavy smudge. It may only be a mixture of bullet lubricant and powder fouling, but it usually requires a little rubbing to remove it and oftentimes shows a distinct lead color. The lead is easily rubbed off, but it had to come out between the barrel and the cylinder before the bullet passed into the barrel. The heavier the loads the more pronounced this condition will be.

Before sneaking out from under this subject of leading once more, I would like to say that the condition which frequently occurs in revolvers where a deposit of lead is left around the rear end of the barrel but does not increase appreciably with continued firing, I do not consider leading, nor do I believe any particular attention should be paid to it other than from an experimental standpoint. When I test a particular gun, bullet, or kind of lubricant for leading, I fire a maximum of 300 shots. That is about as much as a gun is likely to be fired without cleaning in one day and if, after firing 300 rounds, the accuracy is not impaired, I do not consider that the gun is leaded, regardless of any minor deposits of lead that it may have in the barrel. Leading is a practical problem and it is only of importance when it affects accuracy adversely in a comparatively short series of shots. I have very little sympathy for these “nuts” who let out a wail of woe over a few little specks of lead in a revolver barrel that can be taken out with a couple of pokes of a brass wire brush.

Selection of Cases.

The newer so-called high speed or high velocity revolver cartridges are loaded up to pressures of around 20,000 pounds per square inch and such a pressure is too high for absolute safety in a folded head case, when used in an arm having as much head space as a revolver. Solid head cases also have thicker side walls and consequently a somewhat smaller powder capacity than folded head cases of the same caliber. With any given charge the density of loading will be greater in a solid head case than in a case of the folded head type, all other loading conditions being equal. The difference is not great, but anyone wishing to get the best of accuracy should sort out the two types of cases and not mix them in loading or firing.

Resizing Revolver Cases.

Resizing revolver cases full length will make no practical difference insofar as accuracy is concerned but as new or resized revolver cases are usually a pretty free fit in their chambers, a considerable amount of expansion takes place and continual resizing of these cases, which are relatively thin as compared with most rifle cases, will shorten their useful life slightly. If the reloading tool used is one that holds the cartridge case in a vertical position while being loaded, complete resizing of the case or at least resizing of the muzzle end will be necessary, as otherwise there will be nothing to prevent the bullet from dropping freely into the case to too great a depth. If the cases are cannelured and the cannelure hasn't been ironed out enough by previous firing, this will act as a stop for the bullet. As a matter of fact it was for this purpose that cases were originally cannelured, but the trouble with depending upon the cannelure as a stop for the bullet base when loading cast bullets is that there is no uniformity as to the location of cannelures in different lots of cartridge cases; furthermore, the variety of shapes and lengths of cast bullet is so great that it will be a matter of chance as to whether the distance from the base of the bullet to the crimping groove will be the same as the distance from the cannelure to the mouth of the case.

The use of un-resized cartridge cases in a revolver is perfectly permissible and is, theoretically at least, desirable but as the bullets must be held in place by the crimp alone, they can usually be rotated with the fingers after they are crimped. Many of the present day cartridge cases are quite soft and after being reloaded a few times, even with normal loads, they are apt to be a pretty tight fit in the chambers and some resizing is necessary.

Neck Resizing. As far as shooting is concerned, reducing the mouths of the cases to hold the bullets friction tight does not possess any particular charm from an accuracy standpoint, but this is not a bad practice by any means, for in addition to the crimp it offers additional insurance against the cases working off from the bullets under the influence of recoil.

Crimping.

Regardless of whether the bullets are seated friction tight or not, revolver cartridges should always be crimped and *crimped heavily* as the resistance of the crimp is necessary to promote proper combustion of pistol powder charges. When a bullet is seated, the lubricant rubs on the inside of the case neck, forming a thin film between the bullet and the case, and the force required to pull the bullet from the case will be less than if the bullet were dry. When the arm is fired it is thrown abruptly to the rear by the recoil and the cases of the cartridges in the remaining chambers, because of their lighter weight and lesser inertia, have a tendency to move to the rear quicker and at a higher velocity than the bullets in them. This sometimes causes the cases to strip off from the bullets slightly with each shot, thereby increasing the over-all length of the cartridges. The condition is usually attributed to the bullets working out of the case, but it is usually the reverse; the cases work off from the bullets. The net result is that sometimes a cartridge lengthens enough so that a bullet projects from the front end of the cylinder far enough to interfere with rotation. This also causes a slight increase in the air space in the case that is not particularly desirable, while the malfunctioning of the arm is an entirely unnecessary nuisance. Proper crimping of the cartridge will prevent this.

To get back to so-called bullet jump or an elongation of revolver cartridges from recoil; this is an important consideration. The only American revolver using a cartridge that is not normally crimped is the Model 1917 revolver or revolvers using the ·45 Automatic pistol cartridge. This cartridge is made primarily for the automatic pistol and is positioned in the barrel by the forward edge of the case coming in contact with a shoulder in the chamber. This contact also supports the cartridge against the blow of the firing pin. Revolvers using this cartridge are chambered on the same principle and the clips commonly used in revolvers are for the sole purpose of affording extraction. However, in actual practice these clips many times support the cartridge against the blow of the firing pin.

Anyone who has used the caliber ·45 automatic pistol or revolvers for this cartridge has probably at some time or other encountered ammunition having several indentations around the necks of the cases that appear to have been made with a prick punch. As this type of cartridge must be made to serve interchangeably in the revolver and the automatic pistol, at least for military service, it cannot be crimped. The indentations are used in lieu of a crimp to prevent the cartridges from lengthening excessively from recoil, when fired in the revolver. Indentations of this kind are practical in ammunition loaded with a hard metal jacketed bullet but would serve no very good purpose if the ammunition were loaded with a lead alloy bullet,

In order to check the elongation of this cartridge when fired in a revolver with cast bullets, the writer conducted a test a number of years ago of the following nature and results: Fifty test cartridges were loaded with 5·9 grains of Pistol Powder No. 5 and a 220 grain cast bullet having a single lubrication groove. The bullets were, of course, seated friction tight in the cases. Each of these cartridges had a file mark in the head for identification purposes and each one was loaded in the cylinder with five other loads which were fired. In this way, the test cartridge was subjected to the recoil of five shots. Each test cartridge was measured for over-all length before and after the test and the amount of elongation recorded. The elongation for fifty cartridges varied from ·000″ to ·045″, the mean being slightly over ·018″. The lubricated lead bullets, which incidentally were 10 grains lighter than the service bullet, gave a greater degree of elongation than is permissible in military ammunition, but it is not believed that the elongation which takes place is of practical consequence over ordinary revolver ranges.

The heavier the bullet and the heavier the recoil, the more likely the cases are to strip off from the bullets, but crimping will prevent this fault. With the caliber ·45 Automatic pistol cartridge when loaded for use in a revolver, the case can be tightened slightly onto the bullet by means of a crimping shoulder in the tool, although such tightening should not consist in bending the mouth of the case sufficiently to be worthy of the name of a crimp. This stunt will only work on a bullet that has no crimping groove.

Variations in Crimp. Reloading tools will sometimes turn a crimp that is not uniform. The case may be severely crimped on one side and not at all on the other. This is due to several causes. The brass from which the case is made may be slightly softer on one side than on the other, causing it to collapse more easily. Sometimes the case is a little smaller in diameter than the crimping chamber, so it slides to one side and bears harder on one side than the other. The ammunition manufacturer makes cases within very close limits and his crimping dies are made to handle new and uniform cases. This represents an ideal condition; but, in spite of this, the reader would find plenty of factory loaded cartridges with variations in crimp if he were to inspect a lot of ammunition after it came from the machines. True, these variations would be much less than are ordinarily found in handloaded ammunition, which may make it appear that reloading tools are not properly made; but this is not true. The loading tool manufacturer has a harder problem with which to contend than the ammunition manufacturer, because the reloading tools must be made in such a way that they will handle cases that have been *expanded* from firing. For this reason, the reloading tools are made to meet the requirements of the *expanded* case. When *a new, resized,* or only slightly expanded case (from a close chamber) is used in one of these tools, there is a certain amount of play between the case and the parts which guide it. Sometimes the irregularity of crimp that results is very noticeable. The cartridge can be turned half way around and forced against the crimping shoulder a second time to help equalize the crimp if desired. Reloading tools that resize cases in the normal operation of the tool and, consequently, perform their operation on cases of a uniform size, have a little better chance of turning a uniform crimp than others, but a certain lack of uniformity of crimp is inherent in all reloaded ammunition.

If a cartridge could be fired in such a way that the gas pressure would not force the crimp out and *if* there were no throat or guide for the bullet as it left the chamber, the drag of the crimp would, without doubt, cause the bullet to tip more or less. But a revolver cartridge cannot conceivably be fired under such conditions. The gas pressure *does* relieve the crimp and the bullet *is* guided into the barrel, so the amount that the crimp can possibly tip the bullet is limited to the tolerance between the bullet and the throat of the cylinder. An undersized bullet will presumably show the effect of an irregular crimp more than one that is of correct diameter. I say *presumably* because I have never been able to detect any increase in dispersion from this cause from ordinary firing, nor to test any such ammunition in any device that was sufficiently accurate to definitely show that any slight enlargement of a group was due to the crimp. If the reader wishes to try an interesting experiment, load some revolver ammunition without crimping the bullets. Then, with a cold chisel or a screw driver, knock a heavy crimp in one side of the case. Then take the ammunition out and shoot it and see if you can detect any difference in accuracy over your regular product!

The object of these observations on crimping is not to create the impression that poorly crimped ammunition is desirable—uniformity, whether it be the crimping or any other detail of reloading, is and always will be conducive to the best accuracy. On the

other hand, it is possible to get an exaggerated idea of the importance of little variations, hence the advice that the reloader of revolver ammunition save himself needless worry over a little irregularity in the crimping of his cartridge.

Revolver Bullets.

Revolver bullets are essentially confined to the lead alloy variety. The *easiest* way to obtain revolver bullets is to buy them and the cheapest place to buy them is from one of the ammunition manufacturers.

The *cheapest* way to get cast bullets is to cast them yourself. You will save money and will have absolute control over the hardness and perfection of your bullets.

Regardless of how you get them, the *selection* of bullets will depend upon the use to which they are to be put. If you are a peace officer who may have to stake his life on a knock-down shot at short range and equally short notice, get the most powerful factory loaded ammunition available and don't monkey with hand loads except for practice. If you belong to the regiment of big game hunters and are interested in revolver loads for use on big game, you will probably want one or another of the so-called “man stopper” bullets (most of which, by the way, never stopped a man). But if, by chance, you belong to the great army of target shooters who persue the elusive bullseye for the sheer enjoyment of the game, you will derive the greatest enjoyment and success from moderate loads.

The large number of different shapes and weights of revolver bullets for which bullet moulds are obtainable, often makes it difficult and confusing for the novice to make a proper selection. Generally speaking short, stubby, light weight bullets will only perform well with reduced charges and at short ranges, while bullets approximating the length and weight of standard factory bullets of their caliber will usually perform well with reduced and full charges at least up to the longest conventional revolver range of 50 yards. I say usually, because there are a few bullets for which moulds are available that have no rhyme or reason for their design. Fortunately however, the majority are bullets that were patterned after older ones which have preceded them and even though the designers may have known little or nothing of bullet design, the pattern they have attempted to improve upon has been a guiding light. As a matter of fact, revolver ranges are so short that almost any slug approximating the conventional limits of weight and shape will shoot pretty well regardless of which end is loaded into the cartridge case first, so the selection of a revolver bullet is not particularly difficult, A good rule of thumb for the beginner is to use the so-called standard bullets as recommended for any particular caliber by the manufacturers of bullet moulds. Of course, if one is associated with other revolver shooters who reload their own ammunition, their experience is always a helpful guide, but in the absence of this, the standard bullets are the best bet to start out with. Later on, one can try something different.

Wad Cutter Bullets. This type of bullet mould has an appeal to the target shooter because of the clean hole it cuts in the target, but generally speaking sharp shoulder bullets are ballistical monstrosities. They are essentially cylindrical slugs with lubrication grooves in them, having a flat nose or at best a flat with a stubby projection in the center which serves no particular purpose. That good accuracy can be obtained with them is due principally to the short ranges at which they are fired, the air resistance on the flat nose hardly having time to make itself felt before the bullet reaches the target. Some of these bullets, however, have an elongated projection on the nose which does stick out far enough to break away through the atmosphere so that the bow wave created by the forward end of the bullet clears the sharp shoulder. Such bullets are much more stable in flight than those with flat or practically flat faces. The latter are usually unstable in flight and show some signs of tipping on the target, but this does not mean that they are inaccurate. While those with the longer projecting points are more stable and the best of the two for all around purposes, they are not *always* stable in flight. Either type when fired with reduced loads will tip or key hole in a strong, cross wind.

The stability of a bullet is dependent upon the speed of rotation and the speed of rotation depends upon the muzzle velocity. For simplicity let us suppose that the rifling in the barrel of a revolver has a pitch of one complete turn in 12″. If a bullet is fired with a muzzle velocity of 500 feet per second it will rotate at the rate of 500 revolutions per second but if the same bullet is given a velocity of 1,000 feet per second it will rotate twice as rapidly. The rotational velocity of a bullet is the muzzle velocity in feet per second multiplied by 12 and divided by the number of inches in which the rifling makes one complete turn.

In spite of its ballistic faults the sharp shoulder bullet is by no means to be condemned. Factory cartridges loaded with such bullets usually have charges of powder somewhat below the full service loads for the same caliber. These so called “mid range” loads, because of the lessened recoil, are excellent for target shooting and some of the ammunition manufacturers are producing loads of this type of such a high degree of accuracy that the reloader will be put to special pains to duplicate them.

Hollow Base Bullets. The early breech loading revolvers had chambers that were straight cylinders from one end to the other. They used cartridges loaded with bullets the same diameter as the outside of the cartridge case, except for a heel of smaller diameter which fitted the inside of the cartridge case. The bullets were lubricated on the outside by dipping them into melted lubricant after the cartridges were loaded and were crimped in place by a crimp which was rolled in. Such cartridges were only loaded with black powder and they were for the most part only fairly accurate. The small diameter heel would upset irregularly on firing, creating the equivalent of an imperfect or lopsided base. Incidentally, cartridge cases for outside lubricated cartridges are no longer manufactured and in reloading such ammunition there is no possible way of crimping the cases onto the heel of the bullet, consequently, the reloading of such revolver ammunition is impractical and unsatisfactory as the cartridge cases are bound to work off from the bullets under the influence of recoil.

The outside lubricated cartridges were messy and to overcome this, grooves were put into the bullets, which were made small enough in diameter so their cylindrical bodies would fit inside of the cases; the cases were then lengthened to cover these lubricating grooves. This made the bullets entirely too small to fit the rifling. These did not shoot with any accuracy at all. It was necessary to make the bullets of soft alloys and with deep concavities in the bases so that the bases would expand readily and take the rifling. These hollow bases were especially necessary with smokeless powder charges which did not cause as much upsettage of the bullet base as black powder.

Modern revolvers are chambered for these inside lubricated cartridges and furthermore the barrels are bored and rifled for the smaller sized bullets.

Hollow base bullets should never be used in a revolver with heavy charges as such charges will cause the bases to upset excessively between the cylinder and barrel, causing pressures to rise above the expected point. With the following exceptions, there

is no object in using a bullet with a hollow base in a revolver if the diameter of the bullet is as great as the groove diameter of the barrel:

A hollow base lightens a bullet, so that by making a hollow base bullet the bearing surface can be lengthened without increasing the normal bullet weight.

Some sharp shoulder bullets are seated deep in the cases to improve the performance of the powder charge. If these bullets had flat bases the density of loading might be too high and the powder charge would have to be reduced. A hollow base makes it possible for the manufacturer to control the density of loading or the air space over the powder charge to suit the needs of any particular charge and lot of powder. These deep seated bullets, because of the longer jump before they strike the rifling, have more slippage but the longer bearing surface made possible by the hollow base helps to straighten them up and offsets any evil of the longer jump.

But hollow base bullets are hard to cast. Furthermore, to make the nice calculations necessary to control the volume of the cavity in the base in order to get the best results with any particular kind and lot of powder requires facilities beyond the reach of the reloader. Good results may be obtained by loading in this way, but better average results will be had if flat base bullets are used and are seated to a normal depth.

Primers and Priming.

Revolver primers are of two sizes: a large size having a diameter of ·210 inch and a small size measuring ·175 inch. The caliber ·45 Automatic Pistol cartridge, which can be used in the Model 1917 revolver, is loaded commercially with the large revolver size; but most of the ammunition of this caliber *made for or by the U. S. Government,* takes a special size primer with a diameter of ·204 inch, which must be obtained through the Director of Civilian Marksmanship.

While all manufacturers make primers of the same diameters, they are by no means the same otherwise. Some are higher than others, and the primer pockets in the cases are correspondingly deeper; but these differences in dimensions are usually so small that any make of primer can be said to be interchangeable in all makes of cartridge cases taking that size.

Every ammunition manufacturer has his own priming formulas and there are no two of these exactly alike. This means that the flash and heat developed by different makes of primers is not the same. When ammunition is made, the flash hole or vent in the bottom of the primer pocket is made of a size suitable to give proper ignition with the *particular primer* with which that lot of ammunition is loaded. Let us assume a situation requiring an exceptionally large vent. If these cases are reloaded with another make of primer, intended for use in cases with small vents, a higher order of ignition will be obtained and the chamber pressure will be increased. The increase is not apt to be dangerous with any normal load, but it would be with a maximum load. Now, if we reverse the process, and load the weaker primers into cases with small vents the ignition will most certainly be insufficient, even though the ammunition *appears* to shoot alright. Needless to say, a mixture of ammunition loaded as above could hardly be expected to give the best results.

It is advisable, for the above reasons, to use primers of the same make as your cartridge cases, not only to insure a proper fit and depth of seating, but to insure proper ignition of the powder charges.

Before seating fresh primers the primer pockets should be inspected for excessive fouling or corrosion and for breaks in the "webs" or bottoms of the pockets. Of the three, fouling is the least important and will seldom be present in a quantity that will be injurious to good ignition. Enough fouling may, however, be imprisoned under the anvil to cushion the blow of the firing pin.

Corrosion is a worse evil. Primers will not seat smoothly in corroded pockets, and if the primer cups are thin and soft (as they are in at least one make of primer) the primer may be deformed and the anvil cocked, i.e., both sides of the anvil will not bear evenly on the bottom of the primer pocket.

Cracked and broken webs are the worst offenders. Fortunately, they are not of very frequent occurrence except in the larger revolver calibers, when they have been fired with mercuric primers. The effect that mercuric primers have on brass is described elsewhere in this book. In this connection it is well to remember that factory ammunition is not loaded with the same primers as those available for reloading purposes. Much factory ammunition is still loaded with mercuric primers, so it is well to inspect the webs before re-priming the cases. If the web is broken away completely the blow of the firing pin may drive the primer through the bottom of the primer pocket without firing it at all or, at best, give a low order of ignition. If the web is cracked a greater amount of flash than normal will reach the powder and increase its rate of burning and pressure.

There is another objection to cracked webs. It is estimated that the pressure built up in the *primer pockets* of high power rifle ammunition does not exceed 5,000 pounds per square inch, even though the chamber pressure may be as high as 50,000 pounds per square inch. The reason for the low primer pressure is the small vent through which the powder gases must pass. In revolver cartridges, the primer pressure is less than 5,000 pounds, but if the webs are broken the powder gasses can easily pass into the primer pockets and drive the primers violently back against the recoil plate setting this part back and necessitating sending the revolver to the factory for adjustment.

Primer Seating. Everything that has been said relative to seating primers in rifle cartridges applies equally well to revolver cartridges, although minor faults in primers and primer seating will not make themselves as apparent in revolver ammunition as in rifle ammunition because of the greater intrinsic accuracy in rifles, the longer ranges at which they are used, and the smaller groups that are expected from them. This, however, is no reason for being careless in the seating of primers for the hand gun. Special care must be taken, however, that primers do not project in the slightest degree above the heads of revolver cartridge cases. The recoil of the gun throws the unfired cartridge back violently and as some of our modern primers are more sensitive to shock than the older varieties, a high primer might be discharged on impact with the frame of the gun, and the chamber not being aligned with the barrel, the bullet might strain the gun in some way, if its departure were obstructed by the forward part of the frame.

Powders and Powder Charges.

The powders best suited for use in revolvers are Hercules Bullseye and Unique and duPont No. 5, No. 6, and No. 80. Unique and No. 80 are primarily rifle powders but give excellent results in revolvers. Unique is especially desirable for higher than normal velocities without exceeding recommended pressure limits. No. 80 is intended to burn at higher pressures than are ordinarily

developed in revolvers and consequently does not burn completely in revolver loads, but this is of minor importance. The important thing is to have the same amount of powder burn each time and No. 80 does this, consequently it gives good accuracy. The other powders are made especially for pistols and revolvers and will be found better suited for general use in such cartridges. They will ignite more easily with revolver primers and burn better than the rifle powders. The choice between them is largely one of preference.

Any of these powders can be measured with satisfactory accuracy with the Ideal, Bond, or Belding and Mull mechanical powder measures. For all normal charges these measures can be set according to the tables furnished with them without the aid of a scale or balance. Setting the measures by the tables may give a charge slightly different from the charge desired, but it will be safe and close enough for all practical purposes. If a charge of an exact given weight is desired, the measure should be set with the aid of a scale or balance as previously described.

Dip measures or scoops are not generally recommended for use with dense smokeless powders. They must be used with great care in order to get uniform charges, and if one has scoops for several different powders there is always a chance that the wrong scoop may be used with disastrous results. However, the scoop or dip measure can be used with reasonable satisfaction if the precaution is taken to make it so it cannot possibly hold an over charge. Belding and Mull will make up scoops for smokeless powder charges to special order or one can make his own from a black powder scoop or an empty case filed down to hold the proper charge.

A five-cent aluminum funnel forced into the end of a short drop tube of an Ideal Powder Measure makes a very convenient arrangement for pouring the charges into the cases. Need we caution against pouring two charges into one case?

A loading block is a practical necessity to the reloader. They can be purchased or made by boring a series of holes of the proper depth into a piece of board. Bullets should never be seated in cases without first inspecting the powder charges. If the charged cases are put in a loading block, the block can be tipped towards a good light and the height of the charges observed. An overcharged case will be apparent at once. In the manufacture of ammunition electrical or mechanical gauges or visual inspection is always used to verify powder charges before the bullets are seated and the hand loader cannot afford to be less careful.

Chapter Fourteen

LOADING FOR AUTOMATIC ARMS.

When loading ammunition for hand operated rifles, single shot pistols or revolvers, the prime limiting factor is the chamber pressure. If the cartridges for any of these arms do not develop pressures in excess of those dictated by experience and good judgment and the ammunition is accurate, it can be considered as perfectly satisfactory.

This is not always true of ammunition intended for use in the so-called “automatic” or self-loading arms for, although the pressures must be kept within safe limits, there are other factors which inject themselves into the situation. Automatic rifles and pistols depend for their functioning upon the use of a certain amount of the energy of the cartridge fired in them. As this energy is exerted to the rear, it is necessary to pay particular attention to it when loading the ammunition. In the hand operated arms, we think only of the effects produced upon the bullet and the movement of the bullet in a forward direction, but the peculiarities of the automatics make it necessary to “think in two directions.”

It is possible to reload ammunition with cast bullets that will cause severe battering of the moving parts of an automatic arm, even though the pressures developed are well within the recommended limits for the arm. The points to be observed in loading ammunition for the automatics depend upon the mechanical principle of operation of the particular type of automatic arm that the ammunition is being loaded for. All self-loading arms do not work on the same principle and to understand the points to guard against in loading ammunition for any of them, it is first necessary to know in a general way how these arms operate. They are all the same in that firing a cartridge causes the breech to open, the cartridge case to be extracted and ejected, the arm cocked, a new cartridge to be pushed into the chamber and the arm left ready to be fired again by another pressure of the trigger—but the method by which these several things are accomplished differs.

The three general classifications of automatic or self-loading arms as they should more properly be called, are: blow-back, recoil operated, and gas operated. A fourth classification might well be placed between the first two and called “delayed blow-back.”

Blow-Back Actions. Blow-back actions are those in which the barrel and breech block are never locked together, the breech block remaining in the closed position only by virtue of the tension of the recoil spring. When a cartridge is fired in this type of action, the cartridge case is driven to the rear by the gas pressure at the same time that the bullet is driven forward. This two-direction thrust is, of course, common to all types of arms but in the blow-back action the head of the cartridge case does not meet the resisting wall of a locked or solid breech— it pushes the movable breech block to the rear. Because of the weight and inertia of the breech block, to say nothing of the resistance of the recoil spring, friction and the effort to cock the piece, the rearward movement of the breech block is very much slower than the movement of the bullet. Consequently, in this type of mechanism the breech block only moves a small fraction of an inch to the rear and is not open far enough to permit the escape of gas by the time the bullet leaves the muzzle. The continued movement of the recoiling parts to the rear is due to the momentum given them during the short period of time the bullet is moving through the barrel. This momentum normally carries the breech block (or slide, in the case of an automatic pistol) to its rearmost position.

The thrust imparted to the breech block depends upon the same factors which govern the velocity of the bullet; namely, the chamber pressure and the manner in which the pressure is developed plus the area on which the pressure works, which can be translated into the area of the head of the cartridge case. For these reasons, the blow-back type of action is limited to the use of low power cartridges and, in the case of pistols, to cartridges of small head diameter. The rifles employing this principle can use larger and more powerful cartridges because of the heavier breech blocks and stiffer springs that can be used in them, but even the rifle cartridges have decided limitations.

Blow-back actions are not adapted to the use of cartridges developing high velocities or high chamber pressures and in reloading ammunition for such arms the loads should never exceed the limits prescribed for standard charges.

All small frame automatic pistols that I know of, whether of domestic or foreign manufacture, up to ·380 caliber (9 m/m short) operate on the blow-back principle. This is certainly true of the Colt automatic pistols in calibers ·25, ·32 and ·380 as well as the ·35 and ·32 S. & W. automatics. Other pistols of this type in more or less common use in the United States are the Ortgies and small models of Mauser automatics, to say nothing of the conglomeration of cheap mail order pistols.

Among rifles, we find only three American automatics operating on the blow-back principle. These are the Model '05 Winchester caliber ·32 and ·35 self-loading rifles, the Model '07 Winchester caliber ·351 self-loading rifle and the Model 10 Winchester caliber ·401 self-loading rifle. Being rifles, and allowing a greater amount of weight in the mechanism than in automatic pistols, more powerful cartridges can be used than in the blow-back pistol actions, but even so the cartridges for these automatic rifles are little more than glorified pistol cartridges.

Any attempt to overload ammunition for any of the arms mentioned, even though the pressures are well below a dangerous point, can only result in injury to the arm. The velocity of the recoiling parts will be increased, this sooner or later will cause damage of one kind or another to the mechanism. The point to remember in reloading ammunition for these arms is that the normal chamber pressure is the limiting factor. Cast bullets, because of their soft nature, will start on their way and accelerate more quickly in a barrel than a jacketed bullet of equal weight and bearing surface. Consequently, it is frequently possible in automatic arms to get higher muzzle velocities with cast bullets than can be obtained with jacketed bullets and furthermore, this can be done without exceeding normal pressures.

Delayed Blow-Back. This is a cross between the blow-back and the recoil operated type of action. In it, the breech block is never really locked to the barrel but there is some mechanical resistance offered to the breech block to delay its initial movement so it will not recoil and open as easily as a straight blow-back action. The only arms that the handloader is likely to encounter which operate on the delayed blow-back principle are the Savage automatic pistols. Practically, the "delay" in operation of these pistols is insignificant, if, indeed, there is any delay at all. Ammunition for them should be reloaded the same as for blow-back pistols of similar caliber.

Recoil Operated Arms. In the recoil operated type of automatic pistol or rifle we have a mechanism that is entirely different in principle from the blow-back and one which requires different treatment in loading the ammunition for it. In this type, the breech block and the barrel are securely locked together at the time the cartridge is fired and normally remain locked until the bullet is out of the barrel. When the arm is fired the barrel and the breech, in a locked position, recoil to the rear together and the energy of recoil is used to unlock the breech from the barrel, permitting the breech block to continue its rearward movement alone, extracting the cartridge case from the chamber and performing its other normal functions. In this type of action the barrel and breech block can move to the rear independently of the rest of the arm.

Among the automatic pistols operating on the recoil principle, we find all the ·38 caliber Colts as well as the ·45 Government model, the Luger and the military Mausers. There is only one model of American auto rifle using center-fire ammunition in this category; namely, the Model 8 Remington autoloading rifle, which is made for the calibers ·25, ·30, ·32 and ·35 Remington cartridges.

As these recoil operated arms have their breech blocks or slides locked to the barrel it is possible to use more powerful cartridges in them than can be used in a blow-back arm, although even these locked actions have their limitations. During the interval that the two are locked together they recoil in much the same way that a hand-operated rifle recoils when fired. The energy that is imparted to them is influenced by the weight of the bullet, the barrel time and the rate that the bullet accelerates in the barrel. Lead bullets impress themselves into the rifling more easily than jacketed bullets and consequently do not require as high a chamber pressure to develop a given velocity as a metal jacketed bullet. If lead bullets are loaded up to the limit of the permissible chamber pressure the acceleration of the bullet will be greater than a metal jacketed bullet and consequently the velocity of the recoiling parts will be greater. This will lead to more or less upsetting and deformation of the parts of the gun that arrests the rearward motion of the breech block. Many of the loads published in tables of charges do not take this factor into consideration, and it is a good plan for the reloader who wishes to keep his self-loading rifle or pistol in good condition to experiment with reduced charges and find out just how little powder he can use with any given bullet to barely cause the arm to function. With this minimum as a base he can establish his charge somewhere between this point and any recommended load, but should never exceed any recommended full charge whether using lead or metal jacketed bullets. It is also a good plan with any automatic arm to examine the recoiling parts carefully from time to time for any evidence of battering or upsetting, and the first sign of such a condition should be heeded and the load reduced slightly.

The positive functioning of self-loading arms requires that the cartridges enter the chamber freely. Therefore the chambers are apt to be a little large. This condition may result in excessive expansion of the cases and tearing of the brass in the solid head of the case. This condition is described in detail under the subject of Resizing Cartridge Cases, but in order to be sure of proper functioning it is almost always necessary to resize the cases to their original dimensions. It depends upon the particular type of arm and the nature of the loads used. For example, the Luger, Mauser, ·32 Auto and ·380 Auto cartridge can sometimes be reloaded several times without resizing the cases. On the other hand, the ·45 Auto and most of the automatic rifles are apt to malfunction if the cases are not resized full length every time they are reloaded. As previously mentioned, the resizing of cases that have cracks or tears in the solid heads is not desirable, but rarely causes any trouble when moderate loads are used except in the Cal. ·45 Automatic Pistol. This caliber, while by no means dangerous to reload, is nevertheless worthy of special attention.

Reloading the ·45 Automatic

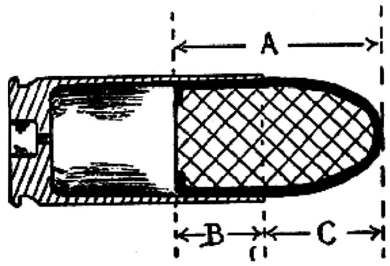
This cartridge because of loose chambering and poor support at the lower part of the chamber where the metal is beveled to permit easy feeding of the cartridges from the magazine, bulges considerably at the head when fired. This causes cracks to occur in the solid head. The case is so large in diameter and so short that it is easy to inspect them for this defect by merely looking into them in a good light. If they are cracked all the way around the inside of the head it is best to discard them.

The photograph shown on Plate XIX is of a section of a Cal. ·45 Automatic Pistol barrel with a cartridge in the chamber. It will be seen that the cartridge is positioned in the chamber by the square, un-crimped edge coming in contact with the square shoulder of the chamber. This contact supports the cartridge against the blow of the firing pin. The head of the case is flush with the barrel extension. If the cartridge were crimped, it would go deeper into the chamber, the head space would be excessive, and a too light blow from the firing pin would cause ignition troubles.

It can be seen that the underside of the case receives very little support and that the looseness of the chambering leaves a considerable space over the top of the cartridge. This is what causes the case to expand considerably and tear the brass apart slightly inside of the solid head.

Unfortunately, all cases for the ·45 auto are not as long as they should be and before reloading it is well to measure them. They should be from ·892″ to ·898″ long. A simple way to gauge them is to remove the barrel from the pistol and use it as a gauge. Resize the cases and try them in the chamber. The heads should be just flush with, or very slightly below, the projection at the rear end of the barrel. If they project a few thousandths of an inch above this protection it will usually do no harm provided the slide can close and the disconnector can enter the depression in the underside of the slide. The thing to watch out for is *short* cases, and if you find any below the minimum dimension given above or any that seat appreciably *below* the end of the barrel it is best not to reload them.

One is limited in the variations that are permissible either in the weights or shapes of bullets that may be used in automatic pistols as well as in the dimensions of the finished cartridge. Sharp shoulder bullets will not feed properly, but can be used if the pistol is used as a single shot weapon. The standard weight of bullet for the ·45 Auto is 230 grains. If a lighter bullet is used, the gun will shoot lower than normal and a heavier bullet will make it shoot higher, *regardless of the powder charge used.* One is also limited as to the depth to which bullets may be seated. The diagram on this page has three dimensions marked A, B, and C. If the dimension A is moved back, the length of the cartridge will be decreased. This will not usually effect the functioning, but it will increase the density of loading (decrease the air space), which will raise the pressure. If A is moved forward, the over-all length of the cartridge will be too great for it to enter the magazine.



If bullets longer than normal are used and the cartridge loaded to its proper length, the dimension B and the density of loading will be increased and as this would imply a heavier bullet than normal, the pressure and the recoil of the slide will be increased without any benefit in the external ballistics of the load.

The dimension C must be kept reasonably close to the normal for proper functioning.

A word about jamming. Jams are usually the fault of the magazine. If the lips become spread too much the head of the cartridge will jump out too quickly. If they are bent in too much they will not let the head come up quickly enough and the slide will ride over the head instead of pushing it into the chamber. In either case, the slide may catch the cartridge in an abnormal position and cause a jam. This assumes that a bullet of the proper shape is used and that the projection of the bullet (dimension C on the sketch) is correct. The nose of the bullet should be rounded and more or less the same shape as the factory bullet.

Cast bullets for automatic arms may be any temper that one wishes to use but hard bullets resist deformation in handling and loading and in arms where the bullet rubs on the chamber wall while passing from the magazine into the chamber hard bullets will have less “drag” than soft ones. This doesn't make any noticeable difference in functioning except when loads are reduced to an extent where they will barely function the mechanism.

Gas Operated Arms. This type of automatic is of little interest to the handloader for, in order to utilize the gasses of combustion to operate the mechanism the weight of the arm is usually increased to a point that renders it unsuited to sporting uses. With one exception, this principle is found only in military automatics or machine rifles and machine guns. The one exception is the Standard automatic rifle, now obsolete, which was chambered for the Remington automatic rifle cartridges. This arm was not a bad one and was unique in that it could be functioned either as an automatic or as a hand operated, slide action rifle. There are still quite a number of these Standard rifles in use and they are much liked and sought after by those who are familiar with them. If used as hand operated arms, the reloading of ammunition for them is subject to the same loading principles as that for any other manually operated rifle of the same caliber. As an automatic arm, little departure can be made from those loads which duplicate or approximately duplicate, the factory standard cartridge.

In gas operated arms there is a hole or port in the barrel at some distance back from the muzzle or some device at the muzzle that permits some of the gas behind the bullet to be utilized in operating the arm. As the bullet passes the port, some of the gas escapes through the port and acts on a piston or other movable member, the motion of which unlocks the breech block or bolt and imparts the necessary movement to it. As these arms are designed for use with military or commercial ammunition developing relatively high pressures, they will not function with reduced loads or with quick burning powders. The pressure remaining behind the bullet must be high enough to function the arm when the bullet passes the point in the barrel where the gas escapes to act on the operating mechanism.

CHAPTER FIFTEEN

LOADING FOR EXTREME ACCURACY.

"Loading for extreme accuracy" has been a stock phrase in most of the handbooks on reloading. Personally, I don't know how to define the phrase "extreme accuracy" as related to handloading. It can't be reduced to arbitrary group sizes and in some arms the accuracy may only be mediocre, in spite of any extraordinary pains that may be taken in assembling the ammunition. The best interpretation I can place on this oft repeated phrase is, *loading ammunition so as to develop the very best capabilities of a particular arm for a particular range.* The subject is one that is confined primarily to the loading of rifle ammunition because the pistol and revolver are somewhat limited in their accuracy by design, short sight radius, and certain human limitations in firing them. On the other hand, the rifle can be readily controlled and fired by the shooter to an extent that will reflect almost the limit of its intrinsic accuracy on the target.

To get the best accuracy out of any rifle requires a careful study of the arm as well as care in loading the ammunition. As far as the latter is concerned, the difference between the ordinary loading of ammunition and loading for extreme accuracy is largely one of paying careful attention to small details, any one of which may be insignificant in itself but, the total of which may make accumulative error sufficient to cause some small enlargement of the groups.

In the past few years, several arms and cartridges have made their appearance on the market that developed a high degree of accuracy, higher than was commonly encountered in previous commercial arms and ammunition. There is nothing magic about these arms and their ammunition. Taking the ·257 Roberts as an example, it will be found on analysis that the dimensions of the chambers in these arms bear a closer relation to the dimensions of the cartridges made for them than was formerly common in commercial arms. This is true of the ·22 Hornet and ·220 Swift as well and we find close throating in addition to close chambering, so that the jump of the bullet before it strikes the rifling is reduced. The difference between the dimensions of a maximum cartridge and a minimum chamber in these arms is so close as to approximate the so-called "tight chamber." This means that when the cartridge case expands at the neck, as the gasses develop, the expansion while sufficient to release the bullet and permit the escape of some gas past it to relieve the pressure, nevertheless is so slight that there is little opportunity for the bullet to go anywhere except straight into the barrel. Chamber the 7 m/m, ·30-06, ·25/20 and a hat full of other calibers with an equal degree of precision and you will get extreme accuracy from them also. About the only thing that can be considered as an advance in these new calibers is that the arms and ammunition manufacturers have been able to increase the standard of mechanical accuracy of their products in commercial production.

Another factor which has had a very material effect upon the subject of extreme accuracy is the remaining velocity of the bullet at any range, about which more will be said later. The model 70 Winchester rifle has recently been made available chambered for the ·300 Magnum cartridge and this rifle, equipped with a heavy barrel, has already demonstrated a superior degree of long range accuracy. Is this because there is something magic about the ·300 Magnum cartridge? No. Is it because this particular ·30 caliber barrel is made more accurately than other ·30 caliber barrels? No. It is due to the combination of a good barrel, properly mounted and stocked, and equipped with a good firing mechanism. The barrel is chambered and throated and the ammunition made so that the two fit much more closely than would be permissible, for example, in a military rifle—plus another important factor. Under the subject of exterior ballistics, much has been made of the fact that a high velocity bullet is unstable in the beginning of its flight but finally, according to the bullet design and its speed of rotation, it settles down and flies steadily over a considerable part of its trajectory. As it loses more and more of its velocity, yaw or wobble sets in. For the best of long range accuracy it is imperative that the bullet be driven with a high enough muzzle velocity so that yaw will not have set in by the time the bullet reaches the target. With the ·30-06 cartridge, it is necessary to load the ammunition right up to the hilt in order to get the best long range accuracy, but by the time the bullet has gotten out to 1,000 yards the velocity has dropped down to around 1500 feet per second, which isn't so hot. The larger capacity of the ·300 Magnum case permits the use of different powders and makes possible a higher muzzle velocity and as a consequence a higher remaining velocity at 1,000 yards, with a little better degree of accuracy at the longer range. It takes pains, study and workmanship to bring commercial arms and ammunition to such a degree of perfection and there is a lot more to it than has been mentioned here, but the point I wish to bring out is that there is a very definite ballistic reason for fine accuracy and the principles behind it are not limited to any particular cartridge or calibers of weapons.

Ballistic Fundamentals That Effect Accuracy.

We can't reduce the chamber tolerances in the arms that we already have, in order to make them more accurate than they are, nor can we boost muzzle velocities beyond a point that is consistent with safe pressures. On the other hand, we can oftentimes improve on the normal accuracy of these arms by working on the ammunition and by giving due consideration to the ballistic fundamentals that effect accuracy.

Ballistic Coefficient. In order to explain these fundamentals, it is necessary to go a little bit further into the subject of ballistics and consider the factors affecting the performance of a bullet in flight. Bullets of different shapes, weights and calibers do not perform the same when passing through the atmosphere, some being retarded more than others. In exterior ballistic calculations, a numerical value must be assigned to each bullet, which represents its atmosphere penetrating abilities. This factor is known as the ballistic coefficient and is obtained by dividing the mass of the bullet, or its weight in pounds, by the square of its diameter in inches which gives the sectional density of the bullet, and then dividing the sectional density by a factor of form called the coefficient of form.

The calculation of the coefficient of form is the most difficult factor in arriving at the ballistic coefficient. It may be done approximately by comparing the shape of one bullet with another of a known form factor, but this is unreliable. For accurate results, the bullet must be fired over different ranges and the remaining velocity obtained empirically at different distances from the gun. By working back through a process of elimination, a fairly accurate value for the form factor can be arrived at.

Scribing arcs of circles for comparison with the profile of the ogive, or tapered portion of the bullet, is unsatisfactory for while the word "ogive" is used loosely in referring to the curved or tapered forward portion of a bullet, nevertheless; there are very few bullets

whose noses are truly ogival, the majority are parabolas or tapers, so there is no satisfactory basis for comparison in this way. Furthermore, when a bullet is truly ogival, the shortness of the arc forming the side of its profile makes such a comparison difficult and then the manufacturing tolerances or errors in manufacture can give an error of as much as two calibers in the radius of the arc. However, we are not interested here in the calculation of ballistic coefficients of bullets, but rather only in the fact that there is such a thing and that it has a material effect upon the performance of the bullet in flight.

The atmosphere itself is a troublesome thing in ballistic computations, because no satisfactory fixed means has yet been arrived at for computing air resistance at all barometric pressures and at all velocities. Regardless of the bullet's ballistic coefficient, its performance changes with changes in atmospheric density and with the velocity at which it is travelling at any time. It will also be noted that the ballistic coefficient varies with any change in the weight of the bullet, in its diameter, or in its shape. For example, if two bullets were of exactly the same shape and dimensions but one was a cast bullet and the other a jacketed bullet, there would be a difference in their weights and a consequent difference in their ballistic coefficients. These facts are mentioned as a further amplification of a preceding statement that mathematical ballistic computations are of little or no value to the handloader.

Initial Yaw. When driven from the muzzle of a gun the bullet is unstable during the early portion of its flight, in which performance it is aptly likened to a spinning top. The conventional top, when first spun and when rotated at its most rapid velocity, wobbles about on its peg but finally attains a speed where it settles down and spins quite steadily until its rotation drops off to a point where instability sets in again. The performance of a bullet is quite similar and the bullet likewise settles down to a steady flight until its velocity drops off to a point where yaw sets in again. The causes of initial yaw and yaw are not the same.

In loading ammunition for extreme accuracy, the abnormal conditions which promote initial yaw are of more interest to us than the yaw that takes place during the bullet's so-called terminal velocity, which is reached somewhere in the descending branch of its trajectory. The factors causing initial yaw may be divided into two parts. First: The factors of rotation and atmospheric penetration, which are fundamental physical causes and which reduce as the forward velocity and rotation of the bullet changes until finally the yaw practically disappears. The reloader can only influence these causes within the limits that he can control the muzzle velocity of the bullet.

The second part involves those factors within the bullet itself; these involve manufacturing errors in the bullet and deformations that may take place while it is passing through the bore. These variations, or defects, or the departures from what might be termed a hypothetically perfect bullet, bring about a type of yaw or instability which does not correct itself during the bullet's flight and may increase to a point where the bullet's accuracy is seriously impaired. For example, the ballistic coefficient of a bullet becomes useless unless the bullet is flying truly on its long axis. If there is wobbling or oscillating in flight, the air resistance is increased and the bullet is abnormally retarded in proportion to the increased air resistance. Some of the conditions affecting that part of the initial yaw pertaining to errors in the bullet itself can be eliminated, or at least greatly reduced by a careful selection of bullets and intelligent loading.

Muzzle Loading of Bullets. Many of the old black powder rifles had rather deep grooves in the barrel and a bullet in passing through them had a considerable amount of lead displaced by the grooves. This lead was forced back and frequently formed projecting fins on the bullet base. As these fins could not be depended upon to be uniform, the gas impinged on them differently as successive bullets left the muzzle of the arm, which increased the initial yaw and, in all probability, also caused some deflection of the axis of the bullet from the normal line of flight. To get around this, many of the older lead bullets were made with a slight bevel on the base, which did give improved accuracy where the bevel was concentric with the bearing surface of the bullet.

The fins were entirely avoided by loading the bullets from the muzzle by the so-called Pope muzzle loading system. Heavy barrels for this purpose were made in the usual manner, after which several small holes were drilled around the muzzle and parallel to the bore, to the depth of a couple of inches. These holes were irregularly spaced and sometimes were of slightly different sizes. The end of the barrel was cut off above the point where the small holes ended, this piece being known as the “false muzzle.” The ends of the false muzzle, as well as the muzzle of the barrel, were squared up so that the two fitted together perfectly, after which the rifling in the false muzzle matched exactly with the rifling in the barrel. The false muzzle was fitted with dowel pins and the rifling, in the upper or forward part of it was carefully reamed out leaving it smooth and exactly the groove diameter of the barrel. A short rod, recessed at one end to exactly fit the shape of the bullet nose and having a large knob or flattened palm rest on the other end formed part of the equipment and served as a bullet starter.

The method of using one of these arms was as follows: The powder charge was measured and poured down the barrel, if the arm was a true muzzle loader. If a breech loader, the cartridge case, charged with powder was usually placed in the chamber after the bullet had been seated. The dowel pins in the false muzzle were inserted in the holes in the muzzle and, being unevenly spaced, the false muzzle would only go on in one position, with the remaining rifling in it continuous with the rifling in the barrel. The bullet, cast or sized to *groove diameter* (those who have been bitten with the idea that cast bullets *must* be ·003″ larger than groove diameter take note) was inserted in the smooth bored part of the false muzzle and with the bullet starter was driven or forced into the barrel. The remaining rifling in the false muzzle served to form the rifling impression in the surface of the bullet and as the displacement of the bullet metal incident to this was forward, there could be no fins or projections on the base of the bullet. Once impressed into the rifling of the barrel, the bullet was seated to the proper depth with a ramrod. It is sufficient to state that the accuracy of many old arms loaded in this way was superb.

The formation of fins on bullet bases is of minor importance in modern rifles because of the relatively shallow grooves. With jacketed bullets it is probably of no importance, because no matter how sharply the jacket material is turned over the bullet base its stiffness is such that there is always a slight radius around the bullet base.

Another cause of yaw is the lack of concentricity in bullets. In cast bullets this may be due to slight irregularities in the mould that are not entirely eliminated by sizing and then again it may be due to improper sizing. In jacketed bullets it is due to unavoidable manufacturing tolerances. I say unavoidable because a manufacturer cannot be changing the dies in his machines every time he makes a hatful of bullets and the materials from which bullets are made are also a limiting factor on absolute perfection. Most bullet jackets are made of gilding metal or a similar material in order to avoid the metal fouling that results from the use of cupro-nickel jacketed bullets when driven at high velocities. Gilding metal is a softer and more ductile alloy than cupro-nickel. It is easier to fabricate accurately but is more difficult to bring to a proper degree of hardness by cold work. From the standpoint of hardness or toughness cupro-nickel is superior, but gilding metal is satisfactory. However, in commercial production the points of jacketed bullets may be

very slightly eccentric with relation to the axis of the body of the bullet and this condition when slight, as it usually is when it occurs at all, is very difficult to detect. Spinning bullets is an unreliable method because of the errors that exist in the spinning devices themselves, although if the eccentricity of the bullet points is great enough it can be detected by spinning. Eccentricity of the point also causes irregularity in the ogive.

Bullets are not infrequently slightly out of round but this, as far as the body of the bullet is concerned, is not of serious consequence unless the condition is bad. The bullet in being forced through the rifling will in all probability be trued up, but due to the elasticity of the jacket material may spring back slightly after it leaves the muzzle. Some reloaders have claimed that out of round bullets will definitely not shoot into the same group as those which are round, when fired in exceptionally accurate arms. While not disputing such a statement, I can state definitely that I have fired ·30 caliber flat base bullets that were as much as ·0015″ out of round from a Mann barrel at 600 yards and obtained exceptionally good accuracy with them. This is no defense of bullets that are out of round; in loading for extreme accuracy bullets should be selected that are as near perfect in all respects as possible.

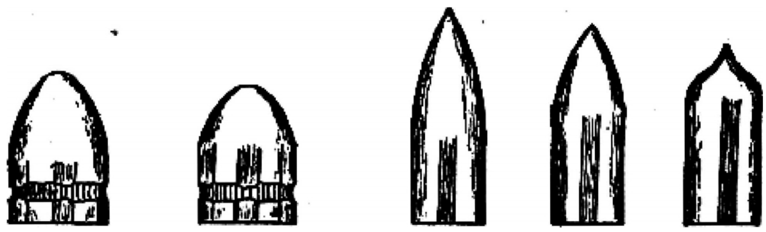
If the body of a jacketed bullet is out of round, in all probability the ogive is also, although this is not necessarily true. In any event, from the standpoint of yaw, eccentricity in the ogive is of more importance than it is in the body of the bullet.

The curvature of the ogives of a lot of jacketed bullets will show some differences. This difference in curvature will not affect the yaw to any appreciable extent but it does affect the ballistic coefficient and will have some affect on accuracy, especially at the longer ranges. Variations in the curvature of ogives is difficult to detect and requires the use of accurately made profile gauges. The manufacture and verification of such gauges is a difficult and expensive proposition, outside of tool rooms especially equipped for the purpose, and the reloader had best forget this unless he himself happens to be a tool maker. In any event, the variations in the ogives of jacketed bullets will not have much effect on even extreme accuracy within the ranges that reloaders ordinarily use their ammunition.

Another source of yaw is imperfect balance in the bullet. Even though a bullet may be of perfect form, its center of gravity may not coincide with the center of form. Variations in the wall thickness of the jackets as well as in the alloy of the core or, in the case of cast bullets, in the mixture of the elements in the alloy, may bring this condition about. When the bullet is passing through the barrel it is rotating around its center of form, but when flying freely through the air it rotates around its center of gravity and if the two are not coincident there will be more or less oscillation of the bullet from this cause. There is no means of inspection whereby such a condition can be detected and while the two centers probably do not coincide exactly except by chance, the chances of their difference being sufficient to cause material errors in accuracy are few.

I presume that if a person who had never seen a bullet read these remarks, he would imagine that a bullet was a sort of misshapen metal affair and that the chances of seeing two that looked alike would be remote, because the average mind is not accustomed to thinking in terms of the small variations that are involved. The accuracy and uniformity of bullets, whether jacketed or cast, is noteworthy; properly used they will give excellent accuracy without any special inspection or consideration by the reloader. This entire chapter is written for those who are of an experimental turn of mind and are continually seeking the elusive group where all the bullets go through the same hole; or for those who seem to get a great deal of their enjoyment out of the mental anguish which they go through in loading their ammunition. I, therefore, pause to remind the reader that the conditions mentioned, while real, are in many instances limited in their importance. They may all occur at the same time without seriously impairing accuracy, as one condition can easily offset another, but if they are accumulative and in the wrong direction, the effect on accuracy will be appreciable.

Upsettage and Deformation. To get back on the track again; when a flat base bullet is fired it suffers a considerable upsettage at the base and in the average chamber may tip very slightly in one direction or another during the time that its inertia is being overcome and it slaps up against the rifling. This shock, coupled with the severe pressure exerted behind it, can easily cause slight deformation in a perfect bullet and as this is a normal and expected condition there is a limit to the beneficial results that can be realized by the careful selection of bullets.



A **B** **C** **D** **E**

A—Revolver bullet, normal. B—Same bullet fired with heavy charge & short barrel, showing upsetting or slugging. Note that bullet is shorter and bearing surface is longer, as shown by greater length of rifling marks. C—30-06 bullet, normal. D—Same, fired with excess charge, showing slugging. E—A bullet recovered from a gun burst by the firing of a terrifically excessive charge of powder which burst the receiver. This bullet did not leave the barrel, but was upset about as shown. Charge was 45 grains of Bullseye in 30-06 case.

In addition to upsetting, there is another factor that causes a change in bullet form while passing through the bore. This is known as "slugging" and is caused by driving bullets with more force than their structure will permit. If a bullet has a thin jacket, the effect of the gas on the base may very easily drive the core into the bullet so as to cause its forward part to bulge more or less, thus changing its shape. If the jacket is too weak, the core may actually be blown through it; while this is a rare occurrence with ammunition that is correctly loaded, it is by no means unknown. Therefore, the rigidity of the bullet must be taken into consideration when loading it, if the best of accuracy is to be obtained. If the deformation due to slugging is appreciable, it will affect both the ballistic coefficient and the yaw, because the deformation is not apt to be symmetrical. It is quite probable that a certain amount of slugging takes place in jacketed bullets in normal high power cartridges, but because of the elasticity of the bullet the latter returns to, or approximately to, the original shape before leaving the muzzle.

When boat-tail bullets are fired they do not upset. The tapered base of the bullet causes the gas to act as a wedge and try to force its way in between the bearing surface of the bullet and the barrel. For this reason, boat-tail bullets must have exceptionally hard cores, as otherwise the gas at high pressure may force its way around the bullet, squeezing its diameter down and consequently ruining its accuracy. Boat-tail bullets are more difficult to manufacture accurately than flat base bullets and it is absolutely imperative that the boat tail be concentric with the point. Special precautions are taken in manufacture to achieve this but these efforts are not always attended with absolute success.

Yaw. With normal bullets the initial yaw dies down shortly after the bullet leaves the muzzle, but the exact distance from the muzzle of the gun that the bullet settles down to fly steadily, or "goes to sleep," depends upon the design of the bullet, its rate of rotation, the muzzle velocity and the degree of yaw that is present. If the yaw is excessive because of defects in the bullet itself, the velocity will fall off more rapidly than normal and as the condition from one shot to another will not be the same there will be a greater dispersion than normal. The further the bullet travels along its trajectory, the greater the effects of yaw or instability become. At shorter ranges they may scarcely be noticeable, while at long ranges they will be marked.

It is believed by many authorities that yaw is the principal cause of dispersion, or the enlargement of groups. Because this instability of bullets or projectiles causes the axis to tip with relation to the normal line of the trajectory and causes not only a decrease in the range because of the abnormal air resistance, but lateral deflection as well, any irregularity in the ranging properties of successive shots can be translated to vertical dispersion on the conventional vertical target and on horizontal targets to an abnormal lengthening of the beaten zone.

It is believed that yaw in artillery projectiles is due entirely to the yaw of the projectile in the gun. An artillery projectile is different from a small arms bullet in nature and performance. These projectiles are made of iron and steel and depend upon their rotation by the rifling upon a "rotating band" of copper, which is shrunk or compressed into a groove at the rear end of the projectile. These rotating bands are sufficiently larger in diameter than the body of the projectile to take the rifling and are of a width that will offer sufficient resistance to the rifling to overcome the straight forward impulse of the projectile. Just in back of the ogive of the projectile there is a carefully machined area slightly larger than the projectile body and with a smooth finish, which is known as the "bourrelet." The diameter of the bourrelet cannot be larger than an easy sliding fit in the bore of the gun it is fired in, and any manufacturing tolerances must be on the minus side. Theoretically the projectile is guided at the rear by the rotating band and at the fore part by the bourrelet, but as there is always a slight amount of play between, the bourrelet and the bore of the gun, the nose of the projectile may, and usually does, follow a set of lands and grooves down the bore with a slight spiral motion and actually yaw in the gun.

A small arms bullet on the other hand, is constructed of material sufficiently soft so that the entire cylindrical portion is impressed into the rifling and it does not have the same opportunity to yaw in the gun that an artillery projectile has unless, of course, it is sub-caliber, but small arms bullets can and do yaw in the barrel because of minor and unavoidable variations in their manufacture or because of deformations caused from the effects of firing. Some of these have previously been referred to.

Chamber and Bore Tolerance. With all the causes of yaw that have been mentioned as pertaining to the bullet, there is also the nature of the arm to be considered. If the groove diameter of a barrel is normal and the bore is over-size, the condition actually may contribute to accuracy rather than detract from it, provided the depth of the grooves is sufficient to impart proper rotation to the bullet. However, a reverse condition of an abnormally large groove diameter, either with or without an under size bore diameter may easily create yaw in the bullet while passing down the bore.

Then, there is always the throat or bullet seat in the barrel to be considered. This is perhaps the most important part of the barrel affecting accuracy and is represented by a bevel in the rifling immediately in front of the chamber proper. The form of the throat usually conforms to the shape of the bullet to be fired in it and this factor must be taken into consideration in designing bullets for any particular arm. It must also be taken into consideration when loading bullets that are of the same caliber but primarily intended for other cartridges than that for which a given arm is chambered.

In commercial and military arms the throat is so formed and located that the bullet normally jumps an appreciable distance before coming in contact with the throat and entering the rifling. The blow thus caused increases the barrel vibrations and may result in some minor deformation of the bullet. This tolerance is necessary in commercial arms to allow for normal variations in bullet shapes and to permit easy loading and functioning. In military arms it must be sufficient for these causes, plus dirt. It is doubtful if the civilian rifleman who practically picks his own conditions for shooting and gives his pet rifle the most tender care has any idea of the severe conditions under which a military rifle must function in the field, but regardless of this, the fact remains that bullets jump forward in more or less of a straight line until they come in contact with the throat in the barrel.

It is not difficult to measure the amount that the bullet jumps in any rifle. To do this, insert a cartridge in the chamber and close the action on it, then push a rod of approximately bore diameter through the muzzle until the end comes in contact with the bullet of the cartridge in the chamber. In this position, put a scratch mark on the rod, even with the muzzle. Then remove the cartridge from the chamber and insert a bullet of the same kind that the cartridge is loaded with, pushing this up against the throat with a short rod or stick. While the bullet is held up against the throat, push the measuring rod against its point and make another mark on the rod even with the muzzle. The distance between the two marks on the long rod will indicate the amount of normal jump.

A rifle that has been fired a great deal, but well cared for, will show a considerable amount of wear or enlargement at the rear end of the barrel. This wear is caused by friction, erosion and probably to a certain extent by the compression exerted by the expanding or upsetting of flat base bullets. As this wear progresses, the accuracy of the arm begins to fall off, being first noticeable at the longer ranges. The bullet continues to have an increasingly greater distance to jump before it strikes the rifling, with a consequent increased deformation of the bullet, which in turn increases the yaw. As the dispersion caused by yaw increases with the range, this explains why some rifles will shoot well at the shorter ranges but will shoot all over the lot at long range.

I am sorry to have taken up so much space on this subject of yaw but it is one of the most important factors affecting accuracy and of the utmost importance to extreme accuracy; unless the reader has a pretty good idea of its causes and affects, he cannot hope to understand the means for reducing it.

Bullet Rotation.

In order to travel on its long axis, the bullet must be given a proper degree of spin by the rifling. The amount of spin necessary depends upon the length of the bullet, which is usually measured in calibers. The degree of spin that a bullet receives is dependent upon the pitch of the rifling and the muzzle velocity of the bullet. In addition to these factors, the amount of spin that a bullet must receive depends upon the range at which it is fired. We have been discussing initial yaw and at the same time using the word yaw rather loosely in referring to it, but yaw also takes place when the bullet has lost too much of its forward velocity and spin in passing through the atmosphere. This yaw begins to take place in the descending branch of the trajectory, or after the bullet has begun to drop appreciably and when the axis of the bullet is no longer parallel to a tangent of the trajectory.

It is, therefore, possible for a long bullet, fired at a moderate velocity, from a rifle having a slow twist of rifling, to be accurate at short ranges but because of its slow spin, yaw will set in more quickly than it would with a shorter bullet fired from the same arm at the same velocity, or a bullet fired with a higher rate of spin. We find examples of this in the old black powder rifles. For example, take the ·32-40. This arm normally has a pitch of rifling of one turn in 16 inches and using bullets well over three calibers in length it has made remarkable groups at 200 yards. Nevertheless, the same loads which have given such accurate results at 200 yards frequently will not shoot for sour apples at 500 because of the slow rotation of the bullet.

While no definite rule can be laid down here for the multitude of combinations of bullets, rifles and loads that are available, to say nothing of the ranges at which they may be fired, it is a good rule of thumb to use the shorter bullets for short range, low velocity loads and the bullets of normal or slightly longer than normal length at higher velocities and at longer ranges, as the increased velocity necessary for the longer ranges will give the bullets a higher degree of spin.

Measuring the Pitch of Rifling. I believe that all handbooks on reloading religiously give directions for finding the pitch of rifling in a barrel without giving the slightest intimation as to why anyone would want to make such a determination. There is, however, a very definite use for a knowledge of the pitch of the rifling in the barrel, especially in loading ammunition for extreme accuracy. If the pitch of rifling and the muzzle velocity are known, the rate of the spin of the bullet is easily computed. If we have a load for our rifle that is giving satisfactory accuracy and we wish to use a different bullet that is of greater or lesser length, we can, by determining the pitch of the rifling, arrive at a rate of rotational velocity of the bullet. If the new bullet is longer, we can with the aid of the pitch of rifling, arrive at a muzzle velocity for it that will give it an equal or greater rotational velocity than the load we have previously been using—always taking into consideration the chamber pressure that must be developed in producing such a velocity.

As to the rotational velocity that any bullet requires, no definite rule can be given here, but a knowledge of the rotational velocity is certainly of as much practical value to the handloader as a knowledge of the muzzle velocity, as the two are inter-dependant.

Instability or yaw in bullets will make itself apparent on the target in the form of slightly elliptical holes, due to the tipping of the bullet. The yaw may only make itself apparent by leaving one edge of the hole darker than the other. Whether this condition is due to unavoidable faults in the arm, the bullets, or both, or merely to insufficient speed of rotation of the bullet can only be determined by experimentation.

The simplest way of finding the rate of twist in a barrel is to use a tight fitting patch in a slotted rod, forcing the patch into the grooves and working it back and forth until it will move with a fair degree of ease. Push the patch down the bore well towards the breech and make a small mark on the top of the rod coincident to another mark made on the muzzle of the barrel. Then draw the rod back until it makes one complete turn, with the mark on the rod coming to the top. Make a second mark coincident with the mark on the muzzle, measure the distance between the two marks on the rod and you will have the distance in which the rifling makes one complete turn. If a slotted rod is used and the patch is a tight fit there is not likely to be any movement between the rod and the patch but even if there is, it will be negligible from a practical standpoint. A little more certain but less convenient way of arriving at the same result is to force a bullet through the barrel so as to impress the rifling into its surface and then solder this slug securely to the end of a rod, after which the slug may be re-entered into the barrel and the same procedure followed as with the patch.

Measuring the Bore and Groove Dimensions.

A knowledge of the bore and groove dimensions of a rifle barrel is desirable when loading for extreme accuracy so that a proper selection of bullets can be made. Of course, sometimes these dimensions will turn out to be so cockeyed that the barrel cannot be properly fitted, but at least one knows where he is at. To do this the barrel should be thoroughly cleaned, oiled with light oil and most of the oil wiped out. It is only necessary to leave a trace of oil in the barrel. A bullet, preferably a cast bullet of pure lead or of a soft alloy, hammered on the end so that it will upset to a diameter larger than the groove diameter of the barrel, is then placed on the muzzle and driven into it with a short rod, taking care that the rod does not strike the rifling. It is advisable to use a piece of brass rod. Any piece of lead can be hammered up into a rough slug for this purpose, but it is important that it be large enough so that metal will be sheared off all around it when it is driven into the muzzle. This will insure a full impression of the rifling on the slug. Once started the slug can be tapped or pushed through the bore with a long rod and caught when it comes out the other end so that it will not strike any part of the gun or drop on the floor and become deformed. However, if it does, don't worry about it, because the deformation will be confined to one edge. It is best to use a slug that is at least two calibers long.

The high spots on the slug will represent the grooves and the low spots the lands, as the surface carries a negative impression of the rifling.

The groove diameter can be found by measuring diametrically across the ridges on the slug but it will usually be found that the diameter measured across the edges of these ridges will be greater than the diameter across the center of the broader surfaces, and the greatest diameter of the slug should be taken as the minimum groove diameter of the barrel. This difference in diametrical measurements is caused by the fact that rifling cutters, used to cut the grooves in the barrel, are stoned or sharpened with the eye alone as a gauge and they seldom cut in a true arc.

Where the rifling has an uneven number of lands and grooves the measurement is not so simple. In such a case it is necessary to measure from the right hand edge of one ridge on the slug to the left hand edge of the ridge most nearly opposite it, The measurements should be taken across several of these diameters and care must be used, as a micrometer caliper has a powerful screw and these edges of soft lead do not offer much resistance. In doing this, don't worry too much about ·0001″, if the micrometer has a

vernier, because the best of hand micrometers will not measure to a ·0001″ with certainty, regardless of the fact that they are graduated in this way.

In measuring bore diameters it is frequently possible to measure across the bottoms of the grooves in the slug, provided that they are wide enough, so that the measuring surfaces of the micrometer will not first come in contact with the ridges on the slug. In case this latter occurs, it is necessary to carefully cut away at least part of these ridges so that the low spots can be measured without interference. Incidentally, any diameter of the grooves in the slug will give the bore diameter of the barrel, because these are true arcs inasmuch as the bore is round.

The measurement of the bore diameter of a barrel with an uneven number of grooves is not so easy as the measurement must be made from the corners of grooves in the slug that are diametrically opposed to one another. This necessitates measuring with the edges of the micrometer measuring surfaces and measuring from an edge is unreliable, but is the best that can be done under such circumstances.

Measuring Chambers. As the dimensions of the chamber have a limiting effect upon the accuracy that can be obtained it is sometimes interesting to compare the measurements of the chamber with a factory cartridge. To make a measurement of this kind accurately is not simple without special gauges but the following method will be found reasonably satisfactory.

Clean and oil the chamber and barrel for about an inch ahead of the chamber. Wipe out all the excess oil so only a trace remains. Plug the barrel with a wad of cotton about an inch ahead of the chamber and stand the rifle on its muzzle with the barrel as nearly vertical as possible. Then melt some sulphur in a ladle that will hold more than the volume of the chamber. If you have no such ladle, use an empty can with one side bent into an acute V for a spout. You will have to rivet a handle onto the can or handle it with a pair of pliers for, while sulphur melts at a low temperature, the can will get too hot to handle. The combustion point of sulphur is low and if you use too much heat in melting it, it will ignite and give off pungent and offensive fumes that are sure to bring you into disrepute with everyone in the vicinity.

When the sulphur is all melted, pour it carefully into the chamber. It will shrink considerably on cooling and you must continue to pour into the shrink hole as it solidifies in order to fill the chamber. When thoroughly hard, the cast can be removed by pushing it out with a cleaning rod. A slight blow may be required to start it and you should be careful that it does not drop and break. This cast will give you a full impression of the chamber, throat and part of the rifling. It is advisable to make such measurements as you want promptly because the cast will warp and shrink after a few hours.

Now that we have the sulphur cast we come to the difficult job of measuring it. Fortunately the neck of the chamber is the most important part and is easy to measure. It is also simple to measure the diameter of the larger end of the chamber but one should remember that the cast is soft and that a light touch must be used. Due to the taper of the chamber one will usually be measuring with the edges of the measuring surfaces which is undesirable but, with care, it should be possible to get within one thousandth of an inch of the correct dimension.

Measuring the diameter at the shoulder of a bottle neck chamber is less easy and reliable, and much will depend upon judgment. At this point it is not only necessary to measure with the edge of the micrometer anvil, but also to measure to an edge on the cast. Furthermore, the “edge” on the cast isn’t an edge at all as there is a radius where the body of the chamber meets the shoulder. It is often difficult to tell just where the body ends and the shoulder begins, but with care the measurement will be close enough for any use a reloader will have for it.

Loading Density and Its Effect Upon Accuracy.

The position of the charge in the cartridge case will have some effect upon the way it burns. For example, let us suppose that a powder charge occupies less than half the capacity of the case. If the charge is distributed evenly along the case when the cartridge is fired, the flash from the primer will sweep across the top surface of the charge. If, when firing the next cartridge, the muzzle of the rifle is elevated and the powder settled back in the rear of the case, the primer flash will penetrate the charge, and a different order of ignition will result. To be sure that the position of the charge is uniform from one shot to another, the muzzle of the rifle should be elevated to settle the charges in the rear of the chamber, and bring the rifle down to the aiming position with as little disturbance as possible. The higher the density of loading, or in other words, the larger the volume of the powder charge in relation to the volume of the powder chamber, the less important the position of the charge becomes. It is of great importance when using small charges of pistol powder in a large case and of negligible importance when full charges are used.

Seating Depth of Bullets.

The accuracy of any rifle can be improved by loading the bullets so they are seated far enough out of the cases to be in contact with the throat of the barrel when the breech block or bolt is closed on the cartridges. This usually makes the cartridge too long to work through the magazines of repeating arms but it has a very beneficial effect on accuracy for a number of reasons.

With the normal amount of jump that a bullet has before coming into contact with the throat of the barrel, it must strike a severe blow against the rifling and it is only reasonable to suppose that this blow increases the intensity or violence of the barrel vibrations. It does not hold that the blow causes a change in the vibration cycle, provided that the direction and force of the blow is always the same, but here is the stumbling block. After the case has let go of the bullet and left it hung in the air, so to speak, it is purely a matter of chance as to what slight angular direction the bullet will take before it strikes the rifling. A difference in the direction of the blow from one shot to another will cause a difference in the character of the barrel vibrations and in the directional movement of the muzzle caused by them. On the other hand, if the bullets are seated out of the cases far enough so they are in contact with the rifling at the instant of discharge, the blow is reduced and as the bullet will normally be pretty well centered by its contact with the throat, other loading conditions permitting, the variation in the barrel vibrations are minimized. There is also less chance for the bullet to become deformed in the barrel. Regardless of causes, reasons, or suppositions, the hard fact remains that any rifle will give better accuracy if the bullets are loaded far enough out of the cases so that they are in contact, or nearly in contact, with the rifling when they are fired. It is essential, however, that all of the cartridges be loaded in the same manner for if one bullet is allowed to jump and strike the

rifling, while another is in contact with it, the finest of accuracy cannot be expected because of the difference there will be in the barrel vibration, which in turn will make some difference in the angle of departure of the bullet.

Because of the lack of shock on the bullet, those that are seated so that they fit against the rifling when the cartridge is fired are less liable to deformation in the bore and consequently less liable to yaw than those that are loaded in the normal manner. If one stops to consider the fine accuracy that is obtained from most rifles using cartridges loaded in the normal manner and from which the bullets jump before they strike the rifling, it will be realized that the benefit gained from seating the bullets in contact with the rifling before they are fired is at best limited. Nevertheless, it is one of the most important things that a reloader can do to obtain the best accuracy from any given rifle. Special barrels, and particularly heavy barrels made especially for target shooting, are almost always throated more closely than ordinary commercial arms so as to reduce bullet jump and special match ammunition is often loaded with the bullets projecting far enough to be in close contact with the throats of the arms they are intended to be used with. A change in bullet shape is sometimes resorted to in order to accomplish this purpose also. This is especially true of long range match ammunition.

To determine the proper seating depth for a bullet, start one into a case for about half of the usual seating depth and try the cartridge in the chamber of the rifle. Do not try to force it, but merely use enough pressure on the bolt to bring the bullet into firm contact with the throat. If the action will not close, seat the bullet a little deeper and repeat the process until the bullet is just in firm contact with the rifling when the bolt or breech block is fully closed. If undue force is necessary to close the bolt and lead alloy bullets are used, the bolt will act as a bullet seater but, unfortunately, some bullets will be forced deeply into the rifling, while others will "back up" into the cases, making for a lack of uniformity,

In loading for extreme accuracy cartridge cases should not be resized full length nor should the necks of the cases be resized to the distance that the bullets are to be seated. Just how the bullet is to be held in place will depend upon circumstances. If, when it is seated to the proper depth, the mouth of the case comes opposite a lubrication groove on a cast bullet or where there is no cannelure in a jacketed bullet, the neck of the case should be resized just far enough to hold the bullets friction tight so they will not fall out from ordinary handling. If there is a cannelure on the bullet that comes even with the mouth of the case or a band or other surface into which the case can be crimped, a light crimp should be used. Either method should leave the bullets so they can be wiggled slightly with the fingers. When a cartridge so loaded is chambered the force necessary to move the bullet in the case will be less than the force necessary to move it off center into the throat and the bullet will properly center itself in the throat. Remember, it is the relation of the bullet to the *throat* of the barrel and not to the cartridge case that counts. Naturally, if the ammunition is to be subjected to much handling the bullets will have to be seated more securely, but for *accuracy* the above method will be found to be the best. The only better way is to go back to the old "scheutzen" bullet seater and load the bullet separately from the case and powder charge.

The importance of the relation of the bullet to the throat at the instant of firing cannot be over emphasized. All the refinements of close chambering have this objective. The neck of the chamber is the most important part and, all other things being equal, a cartridge that fits its chamber closely at the neck when loaded normally will develop better accuracy than one fitting loosely at the neck. The above method of loading in which the bullet is allowed to center itself in the throat will give good results even in a poorly chambered arm.

Alignment of Bullet With Case.

Elsewhere I have stated that it makes little difference how bullets are seated as long as the loaded cartridge is within the tolerances of the chamber it is to be fired in. This means that the bullet must be straight enough so that it will not bind or be forced against one side or the other of the throat. The obvious and logical reason for this statement has also been explained but this does not mean that carelessness or indifference to the way bullets are seated should be permitted, for it is always well to be careful of this detail and seat the bullets as perfectly as possible.

When loading for extreme accuracy, special pains should be taken in seating bullets. If anyone were to hand you some cartridges that had the bullets seated a trifle cockeyed and you didn't get quite as good a group as you expected from your holding, the chances are that you would swear that the trouble was with the way the bullets were seated. Actually, that might not be the reason at all but the assumption is a natural one for any of us; we can see the irregularities in bullet seating but we can't see many of the other conditions that make for the best of accuracy.

If, when loading for extreme accuracy, we take pains with the seating of bullets as well as with all other details of the loading, this mental hazard is removed. We *know* that we have done a good job on the ammunition and, granting the proper shooting ability, if the ammunition doesn't shoot properly, the factors affecting the shooting, both in the arm and the ammunition, can be run down one at a time.

As to the exact methods to be employed in the seating of bullets, I know of no loading tool that will not seat bullets well if it is properly used. Theoretically, the straight line tools have a slight advantage over the tong tools, but actually the former seldom do the better work. The only tong tools in common use are the Bond Model "C," and the Ideal models but these two makes do not work on the same principle. The chambers of the Ideal tools have a recess which guides the necks of the cases before they come in contact with the crimping shoulder and the cases are guided at the heads, but they are forced into the tools practically in a straight line because they can't go anywhere else. This is not quite true of the tapered cartridge uses, as the full guiding effect of the guide hole in the tool does not come into play until the handles are nearly closed.

In the Bond Model "C" tool, the case is not guided at the neck at all. It is only guided by the bushing, and the case muzzle can move about in any direction that the pressure of the closing handles makes it and the bullet, by the resistance it offers, has to straighten the case up. If bullets are seated with too sudden a pressure in this tool, they are apt to seat at a bit of an angle with the axis of the case but with a slow steady pressure they do very well. For the best results, the bullet should be just started into the case, then the cartridge turned half way around to complete the seating. This reverses the direction of thrust imparted by the tool handles and aids in seating the bullet straight. The same chambers used in the Bond Model "D" tool are not open to this objection, as in the straight line tool the side thrust is not present. It is essential, however, that the bullets be started straight with the fingers before completing the seating of them with the tool.

Straight Line Bullet Seaters. In addition to the universal loading tools that perform all of the loading operations, including the seating of bullets, there are the straight line bullet seaters. These bullet seaters, which perform only this one operation, take the form

of a long die with a chamber or recess conforming to the shape of the cartridge they are made for and are similar to a section cut from the rear of a rifle barrel with the rifling reamed out. The “bore” part is smooth and of bullet diameter. The charged cases are entered in the chamber, one at a time and a bullet dropped into the bore base first. The seating of the bullet in the case is accomplished with the aid of a plunger having a recess in its lower end which fits the point of the bullet. Some of the plungers, notably in the Belding & Mull bullet seaters, are adjustable for length so that the depth of seating of the bullet can be varied as desired, but other special tools of this nature are non-adjustable. In principle, this is the perfect method of seating a bullet and in loading ammunition for arms with special barrels and unusually tight chambers, it is the only satisfactory way to do the job.

Some of these special chambers are so tight that commercial ammunition will not go into them. The case necks have to be turned and reamed to make them the exact size of the chamber neck and of a uniform wall thickness. Any irregularity of the case, or angular seating of the bullet, will prevent the cartridge from entering the chamber properly. Straight line bullet seaters for such rifles are usually chambered with the same identical reamer used in cutting the chamber in the barrel; being carefully hand reamed, both chambers are essentially alike. This represents the ultimate in a bullet seater and while such a combination of arm and loading tool is, in a sense, impractical, it does make for fine accuracy.

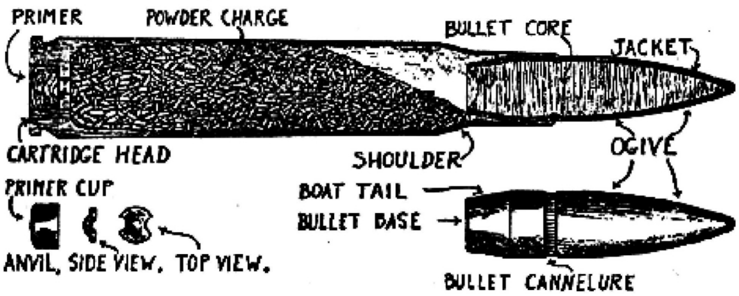
But all the care in the world that may be taken in seating bullets will not make an over-bored or loosely chambered rifle shoot as well as a more perfectly made arm. However, by studying the peculiarities of the arm and using care in the loading of the ammunition for it, the shooter will develop the best accuracy it is capable of.

“Accuracy.”

In discussing the simpler phases of reloading, a number of statements were made regarding the limited effect on accuracy of certain little irregularities such as variations in crimp, imperfections in the points of bullets, etc. From the viewpoint of the average reloader who wants ammunition that is easily and quickly loaded and that will give him a degree of accuracy probably equal to his shooting ability these statements are perfectly true. Any reloader can satisfy himself on this point by deliberately loading cartridges with minor defects of the types referred to and shooting them in comparison with others lacking such defects.

But “accuracy” is an indefinite term. A cartridge that is designed to plow through brush and strike a smashing blow under conditions where game can seldom be seen at as great a distance as one hundred yards need not possess target accuracy. As long as it will group its shots within the vital area of the animal, which may be 8 or 10 inches in diameter it can be called an “accurate” cartridge, yet it would be hopelessly “inaccurate” for target shooting. It is, however, generally accepted that ammunition that will group in three minutes of angle or three inches at one hundred yards deserves to be called “accurate” because it is possible, with care, to machine load ammunition to perform this well. The reloader will ordinarily have no difficulty in loading ammunition with this degree of accuracy, but when one wishes to reduce the group size to two or to one inch at one hundred yards, careful attention must be given to *all* details of loading *and variations must be reduced to the irreducible minimum.*

As the relation between arms and the ammunition for them is such an intimate one it is impossible to consider the one without the other.



“All there is to it”

Priming.

If the proper ignition of a power charge is important in the ordinary run of ammunition (and it is) it is much *more* important when we seek extreme accuracy. The reloader will do well to give special attention to his primers and the way they are seated. All makes of primers do not develop the same flash and heat. One make may be found to ignite some kinds of powders better than another even though both are recommended for the same cartridges. If, in spite of extreme care in loading, the groups have a tendency to string up and down, the primer should be suspected and a different brand tried. The primer pockets in different makes of cases may be of different *depths* even though they are of the same *diameter.* If a primer intended for one of the deeper pockets is loaded into a case with a shallow pocket, the combined effect will be the same as adding a few thousandths of an inch to the length of the firing pin and pierced primers or lesser ignition difficulties may result.

It is good practice to clean the primer pockets with a bit of cloth on the end of a stick. The amount of fouling left by a primer is not of much consequence but sometimes it is of a flaky nature, and if imprisoned under the edge of an anvil it may slightly cushion the blow of the firing pin. Some of the newer primers are quite critical in this respect, and the reloader seeking the finest accuracy should not hesitate to turn to the old reliable (even though corrosive) chlorate primers.

Powder Charges.

The Ideal, Bond and Belding & Mull powder measures will all throw charges with surprising uniformity once they are properly set. In fact, when Capt, G. A. Woody was developing the ·22 Hornet cartridge he found the charges thrown by an Ideal Measure so accurate that he discontinued weighing his charges. All of the above measures are about on a par as to uniformity of charges, but this uniformity *decreases* as the size of the powder grains *increase.* In other words they will not measure coarse grain powders with the same accuracy and uniformity as fine grain powders.

A scale or balance sensitive to one-tenth of a grain is almost a necessity when loading for extreme accuracy. Any of the scales or balances of the tolerance mentioned that are offered by the reloading tool manufacturers are satisfactory. The Pacific Scale is worthy of special note as in addition to being as accurate as any of the other powder scales it has the added advantage of being inexpensive.

The scale or balance can be used in connection with a powder measure by setting the measure for a charge slightly under the weight desired, dumping the charge from the measure into the pan of the scale, and then adjusting the charge on the scale by adding the small amount of powder necessary to bring the scale to balance. This will speed up the work a little without any sacrifice in accuracy.

While a tolerance of one-tenth of a grain is unnecessarily small in a heavy charge as well as being of doubtful attainment, it is nevertheless advisable to eliminate all possible variations when loading for extreme accuracy. If a greater variation is permitted, and the resulting groups are good except for one or two shots, it is only natural to blame the strays on the powder charges without really knowing whether or not that was the cause. Therefore, regardless of the fact that powder charges can be considered as accurate if the variations are within 1% of the weight, it is advisable to hold the charges as close as the accuracy of the scale used will permit.

Selection of Bullets.

Elsewhere in this book it has been stated that minor defects or irregularities in the sides or points of cast bullets can be ignored provided the bases are sharp and cleanly cast. This is true insofar as ordinary accuracy is concerned, but when one is loading for the finest possible accuracy no defects of any kind should be overlooked. Failure of the bands to fill out as sharply on one side of a bullet as on the other, or the presence of a fold or wrinkle in the point will naturally have some effect on the balance of that particular bullet. Bullets with minor blemishes *may* shoot into the group, but they *may not.* It is best to select only those that are perfect, reserving those with little defects for your ordinary run-of-the-mill target shooting. Cast bullets should be checked for roundness before they are sized. To do this, use a micrometer caliper, measuring the diameter of the bullet at right angles to the joint line and again as near to the joint line as possible. Do not measure it at the joint line as it will probably be slightly larger at this point; the joint line being taken off in the sizing of the bullet All bullets will not measure exactly the same as they come from the mould. That is the reason moulds are made to cast bullets slightly larger than necessary so the little inequalities can be eliminated by sizing them. If, however, the bullets are more than a thousandth of an inch out of round, you may have to use another mould (although you probably won't have to).

Bullet temper may have to be varied in order to improve the accuracy of a load. There is no rule for bullet temper except that the harder the alloy the less temperamental it is likely to be. After you have shot enough groups with a bullet to satisfy yourself as to its capabilities, try the same load with bullets a little softer or a little harder. If you then find an improvement in accuracy change the alloy again and continue experimenting until the accuracy begins to decrease. Only in this way can you find the alloy best suited to that particular bullet and load.

Your bullet lubricant may also have to be given attention. Read the chapter on “Bullet Lubricants” before you begin reloading for extreme accuracy.

When loading metal jacketed bullets for extreme accuracy the bullets should be selected for uniform diameter. Flat base bullets are alright if slightly under the groove diameter, but boat-tail bullets should be full groove diameter. Uniformity is more important than the exact diameter determined upon. To select jacketed bullets a micrometer caliper with a lock or clamp is a convenience. If, for example, the groove diameter of your barrel is ·308 inch; lock the micrometer at ·308, and reject all bullets that pass through. Then reset the caliper to ·3085 inch and reject the bullets that do not pass through. This gives a maximum tolerance of only one-half thousandth of an inch which is pretty close and a tolerance of one-thousandth is permissible. As a rule, jacketed bullets should not be more than one thousandth of an inch larger than the groove diameter of a barrel. The bullets that do not gauge to your adopted standard can be measured and segregated into lots according to their diameters.

For the best accuracy, especially for long range shooting, the bullets should be weighed. One per cent of the weight is a reasonable tolerance, but you can hold them as close as you like. Set the scale for the minimum weight and reject the light bullets. Then repeat the process with the scale set for the maximum weight and reject the heavier ones. The rejects can be separated into lots, but naturally, cartridges loaded with these different lots should not be mixed, as this would put all your careful work to naught. Lead bullets should be weighed *after* they are lubricated as the lubricant is part of the weight that must be driven forward by the charge.

Naturally, a bullet whose axis does not pass through the center of both ends cannot be expected to develop the highest degree of accuracy. Spinning is sometimes resorted to to verify the concentricity of bullets. The body or cylindrical portion of the bullet is either held in a chuck or collet while the bullet is spun or it is rolled in such a way that any eccentric movement of the point (or boat-tail) can be observed.

As to the fineness with which eccentric bullets can be detected by spinning the writer will not express an opinion but will let the following story speak for itself. A certain lot of match bullets were being produced and were being spun to check their concentricity. Naturally, this resulted in some rejections. The writer surreptitiously took a handful of rejects and handed them to the inspector. About one-third of them were passed as perfect. The same trick was tried with the “perfect” bullets. One was rejected.

Nothing in the foregoing remarks is intended to convey the idea that spinning or otherwise verifying the concentricity of bullets is a superfluous or useless operation when loading for the finest accuracy. Factory bullets are occasionally appreciably eccentric, and it is desirable to eliminate such bullets or, at least, to segregate them and use them in ammunition for ordinary shooting purposes. Judgment must be used when spinning cannelured bullets as the canneluring sometimes sets up a little ridge on the bullet that will prevent its being spun evenly and unless the person doing the spinning has had considerable experience he may get fooled and reject many perfect bullets. Spinning lead bullets is a waste of time.

Spinning loaded cartridges for concentricity is also a useless labor. It is the relation of the bullet *to the throat of the barrel and not to the cartridge case* that counts.

Anyone who has reloaded small arms ammunition and has had anything to do with the firing of sea coast cannon could hardly help drawing an analogy between the two. The lone individual who weighs his powder charges and bullets and fusses over little details is often regarded as a harmless lunatic or "nut" by his less enlightened brethren, but let us just draw a few comparisons in his defense.

No battery commander would think of taking projectiles and powder charges out of a magazine and firing them as they are. The paint is first scraped off the "bourrelets" of the projectiles (the forward bearing surface that rides on top of the lands), and they are gauged to make sure they are the right size for the gun they are to be fired in. Any bad burrs or flaws in the copper rotating bands that take the rifling are filed or hammered out. This is the equivalent of the hand loader callipering his bullets.

The next job is to weigh the projectiles and group them according to their weights. Every gun has a "probable error" which corresponds to the grouping ability of a rifle. Projectiles of different weights will give different muzzle velocities. If the projectiles are fired without consideration as to their weights the dispersion will be greater than the probable error of the gun and someone will be in trouble. Therefore, the projectiles are weighed and separated in lots even as we weigh and classify our bullets. There is one big difference in that weighing 12 inch projectiles of a half ton or so each cannot be considered merely a pleasant pastime.

Next the powder charges come in for consideration. In large caliber guns the powder is loaded separately from the projectile. The powder is put up in cylindrical silk bags and for the larger guns the charge is contained in two or more bags for convenience in handling. These bags of powder are weighed also and powder added or taken out to bring them to the proper weight—just as the handloader checks his powder charges on scales after the powder measure has thrown the charge. Now that we have weighed and gauged the "bullets" and weighed the powder charges, let's take a look at the loading process.

The gun, of course, is constantly kept laid by the gun crew on the basis of data furnished by the range finding detail. When all is ready the command comes; "TARGET." Second target in rear of U. S. Tug, General Fulano. Fire four trial shots. Commence firing!

A truck, adjusted to the proper height, and carrying one of our "hand weighed" projectiles, is rolled up to the breech of the gun, as like as not chalked up with pictures, blessings, admonitions and prayers for its arrival at the target Almost before it is in position, the ramming detail have the end of a long rammer against the base. At the command; "Home-RAM" they give the rammer "the works" and the projectile is socked up into the forcing cone of the gun with a resounding "BONG," The projectile truck is pulled out of the way and the powder bags are pushed in, the breech closed and a primer is inserted in the breech block. The gun is tripped and goes up into battery, and at the proper instant WHAM! Off she goes and the recruits start for home.

Now let's take a closer look at the loading operation. The projectile *must* be rammed hard and uniformly, and ramming is the most important part of the loading. If the projectile should fail to stick up in the forcing cone (corresponds to the throat of a rifle barrel) it would not only fail to go where it was intended, but would increase the density of loading and consequently the pressure to a dangerous point. Projectiles that slip back have, can and will raise the devil with a gun and sometimes it doesn't have to happen more than once to put the gun out of commission.

The ramming of the projectile is similar to seating a bullet far enough out of the cases so they will be forced into the throat firmly.

From the sketchy description given I believe it will be perfectly apparent that long range cannon are normally loaded "for extreme accuracy" and that the reloader who takes the pains to apply the same common sense principles to obtain better than normal accuracy from his rifle is anything but a "nut."

Common Sense Reloading.

The old saying that "a little knowledge is dangerous" can, for reloading purposes, be paraphrased to "a little knowledge is sometimes confusing." Beginners at the reloading game are apt to read a lot of explanations and get an exaggerated idea of the importance of little details. The writer has come in contact with many beginners at the reloading game who were overlooking entirely some of the more important simple fundamentals of reloading because their heads were cluttered up with partly digested thoughts about barrel vibration, variations of tenths of grains in bullet weights and numerous other picayune details. Common sense is one of the most important things that can go into the reloading of a cartridge. For the benefit of any beginners at this interesting and profitable pastime who may have become confused by any of the foregoing comments the following brief proletarian remarks are made:

1. Use cartridge cases that are all of one make and primers that are of the same make as the cartridge cases.
2. Wipe the primer pockets out with a piece of cloth on the end of a small stick, and be sure that the primers are seated with an even pressure, but that they are forced fully to the bottoms of the primer pockets.
3. Measure or weigh your powder charges so that they do not have a variation of more than 1% of the weight of the charge. In a 50 grain charge this would mean a tolerance of ½ grain in weight. This is a very liberal tolerance, and charges can easily be held much closer than this,
4. Metal jacketed bullets can be used just as they are purchased without gauging, weighing or spinning because the factory metal jacketed bullets being made today run very uniform.
5. Seat the bullets out of the cases far enough so that they are just in contact with the rifling when the action of the rifle is closed on the cartridge.

If the foregoing simple details are observed and you find on getting out to the range that someone else is getting better results on the target than you are, it will probably be due to the fact that that individual either is a better shot than you are or has a more accurate rifle.

*   *   *   *

Like all other things, whether good or bad, this book must come to an end. In reading over the galley proofs I find many shortcomings in the work; places where other topics, comparisons and explanations might well have been used. However, the book

already exceeds the length stipulated by my publisher and no more can be added to it. It is doubtful if any one book on the subject of handloading ammunition can ever be complete, embracing as it does the broader subjects of chemistry, physics, metallurgy and explosives, all of which are in a state of constant development. The best that can be done is to try and crowd as much information as possible into the limited space allotted and in doing this I have tried to write in a way that will be understandable to the novice at handloading and at the same time make the work useful for the experienced.

Before I set aside the old Royal, which I will do with physical relief but mental reluctance, let me remind the beginner once more that the mechanics of loading ammunition are very simple. It is the attention to, and the understanding of, the smaller details that make the difference between mediocre and good ammunition, I believe that the information in this book, if properly understood and applied, is sufficient to solve almost any problem that may arise. However, if there are any points that are not clear or the reader cannot work out his own salvation from the text, I will esteem it a personal favor if he will write me and state his problem. I will be only too glad to assist him to the extent of my ability.

EARL NARAMORE,
Yalesville, Connecticut.

September 1, 1937.

This manual is one of a series of similar volumes arranged for and published by T. O. Samworth, from his unique book publishing house located on the banks of the Pee Dee river, below Plantersville, South Carolina, and known as the Small-Arms Technical Publishing Company.

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